University of Nottingham
Horizon Digital Economy Institute
Doctoral Training Centre

# The Praxis of Community Mapping in Developing Countries

Mark Iliffe

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# Abstract

This thesis takes a multidisciplinary approach to understanding the characteristics, quality and production of Volunteered Geographic Information (VGI), through examining the emergent method of Community Mapping in developing countries. While a good understanding exists of the nature of the characteristics, quality and production of VGI in developed countries there is little covering developing countries. This thesis reviews the state of the art and theoretical approaches in Geography, Human Factors and Geographic Information Science. Research methods of Human Factors, specifically Cognitive Work Analysis (CWA) and geospatial quality assessment are also discussed.

Through a mixed methods approach, the characteristics of Community Mapping are examined and contrasted against those in developed countries. Consequently the quality of data produced and its mode of production are examined, enabled through the construction of a CWA to situate and explore constraints of the developing world case.

By discussing the results and conclusions of these studies, this thesis provides an agenda for the understanding geospatial data quality in developing countries and, specifically, informal urban areas known by their more colloquial moniker of 'slums'. By involving the community in data production and decision making it adheres to the CWA principles and ethics of respectful, user centric design. In assessing the quality of the data produced and the needs of community members around tools we create design guidelines for the development of future tools. Finally, this thesis considers how the characteristics of Community Mapping could and should be considered in the use and reuse of spatial data by its integration into Spatial Data Infrastructures (SDI).

In conclusion, a conceptual framework for the development of VGI in developing countries is produced, alongside other avenues for further work for the theories, software and communities nurtured as part of this thesis.

# Published Papers

A number of papers have been published and awards received, for the work of this thesis[1].

Towards a Conceptual Framework for Participatory Mapping in Developing Countries, **Iliffe, M.**, Goulding, J., Winsemius, H. GISRUK, Manchester 2017 - *Best Paper Award*

Fusing Drones and Community Driven Data in Tanzania, **Iliffe, M.**, Anderson, E., ESA Earth Observation Open Science Symposium, Frascati September 2016

Towards a Multi-Sensor Geoinformation System for Zanzibar, **Iliffe, M.**, Barthélemy, Y. Makame, MO., Anderson, E., ESA Living Planet Symposium, Prague, May 2016

Using Satellite, UAV and Citizen Data for Flood Management in Dar es Salaam, **Iliffe, M.**, Anderson, E., ESA Earth Observation Open Science Symposium, Frascati September 2015

Ramani Huria and Community Mapping - Towards Free and Open Map Data and Imagery for Dar es Salaam Minja, D, **Iliffe, M**., Anderson, E. UNESCO Technology For Development, Switzerland May 2016

Using Satellite, UAV and Citizen Data for Flood Management in Dar es Salaam, **Iliffe, M.**, Anderson, E., ESA Earth Observation Open Science Symposium, Frascati September 2015

Understanding Community Mapping as a Socio-Technical Work Domain, **Iliffe, M.**, Houghton, R. and Morley, J., GISRUK, Liverpool 2013

Taarifa: Improving Public Service Provision In The Developing World Through A Crowd-sourced Location Based Reporting Application, **Iliffe, M.**, Morley, J. and Houghton, R., AGI GeoCommunity, Nottingham 2012 - *Best Paper Award*

When Gov 2.0 Doesn't Exist: Mapping Services In The Developing World **Iliffe, M.** AGI GeoCommunity, Nottingham 2011 - *Best Paper Award*

[1]Further papers are currently being prepared for submission to ACM SIGSPATIAL, IJGIS, and other journals.

# Data Attribution and Licenses

- Google Maps: "Map data: Google, DigitalGlobe";
- Here Maps - ⓒHere 2015;
- OpenStreetMap data ⓒOpenStreetMap contributors, data available under the Open Database Licence www.openstreetmap.org/copyright
  and www.opendatacommons.org/licenses/odbl. Map tiles where used Creative Commons CC-BY-SA 2.0;
- National Bureau of Statistics - All copyright to the Government of Tanzania
  and to http://opendata.go.tz/en/pages/hakimiliki.

# Acknowledgements

While this thesis is my own work, it would not have been possible without the help, guidance and support of my colleagues, peers and friends.

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To my friends and family, my parents Peter and Rosemary Iliffe who raised and taught me the fundamentals, pushing me further, including, initially, university a long time ago. Andrew Grundy, George Day and Laura Kinley thank you for just being there.

Lastly to Johanna Bromilow, who has supported and tolerated me - at times through gritted teeth - dealing with my constant absence, providing penguins, moles and emotional support.

*"A scholar must be content with the knowledge that what is false in what he says will soon be exposed... As for what is true, he can count on ultimately seeing it accepted, if only he lives long enough"*

*Ronald Coase*

*"Not one action will be adequate, all actions will be necessary"*

*Jon Stewart*

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# Chapter 1

# Introduction

## 1.1 Introduction

Basic informational infrastructures such as census results, demographics and maps are essential to aiding the governance and running of any country. Information generated by these tools locate infrastructure, demarcate land-use and provide information on property rights, among many other uses. Across industrially advanced nations, maps in particular are maintained by national mapping agencies and underpin critical functions of governance in maintaining public services, making this information available to the public or government agencies as the need requires. By contrast, in Industrially Developing Countries (IDCs), the institutions that create maps and associated geospatial data are not as advanced, if they exist at all. This has the consequence that vast swathes of the developing world appear as blank spaces on many maps. Not only is the physical reality much different, but such a situation is detrimental to the ongoing development of the affected countries.

This thesis studies how community mapping might bridge this gap; where the maps and data are produced, not didactically by authoritative central bodies, but by local communities themselves. Despite the success community mapping has had in the developing world, it is important to consider that developing countries are set against an entirely different background. Community mapping, as this thesis establishes, is a socio-technical system composed of many participants, fulfilling interchangeable roles and creating novel data that has not yet been available for IDCs.

Geographically the investigations of this thesis are conducted in Dar es Salaam, Tanzania. It was also necessary to explore other geographic locations (the reasons for this will be expanded in their relevant chapters) to support the rationale and findings of this thesis.

The following sections of this chapter introduce the geographic extent, the research domain,

questions and the contributions of this thesis, lastly describing the thesis structure.

## 1.2 Geographic Scope and Research Background

O'Neill (2000) segments the world into Industrially Advanced Countries (IACs) and IDCs. with respect to the study of the ergonomic design of systems in nations, concluding that respect has to be given to the environment in which a system is developed, with local factors needing to be considered. In defining these terms, the aim is to help with understanding the segmentation of circumstances.

By way of example, let us first consider contemporary maps of an IDC, such as Tanzania. Figure 1.1 and figure 1.2 respectively show the location of Tandale in the central urban area of Dar es Salaam and how it appeared on OpenStreetMap (OSM) in August 2015. The data and detail of the map is evident: roads (main roads, secondary and tertiary roads), footpaths, drains, buildings, places of worship, schools and many other features are now mapped and openly available.

While this is far from complete, it is a clear improvement upon map data prior to August 2011: Tandale was a blank space on OSM illustrated by Figure 1.3. This thesis examines the process behind this improvement as a socio-technical system, by taking an interdisciplinary approach, intertwining theories and concepts from Geography and Human Factors to understand the praxis of community mapping in IDCs.

## 1.3 The Role of VGI and Community Mapping

Volunteered Geographic Information (VGI), a term coined by Goodchild (2007) is used to define citizen generated geographic data. From small beginnings on the Internet, VGI is starting to break the hegemony of National Mapping Agencies (NMAs) and authoritative data providers in the developing world, providing genuine choice to those who wish to consume and use spatial data. Movements such as OSM facilitated this boom in VGI, with the use of OSM reaching into both commercial and governmental realms. Turner (2006) signals this shift in the democratisation of cartography under the broad term, *"Neogeography"* where, due to the lowering of barriers and new technologies, maps can be created by a much wider set of contributors than ever before. The literature focusing on VGI is broadly focused on what is colloquially called the Western world. Analysis of spatial quality in the related research is broadly optimistic about the quality of VGI; however, it fails to consider VGI in other places.

The quality of VGI has been widely discussed by Haklay (2010b), Girres and Touya (2010),

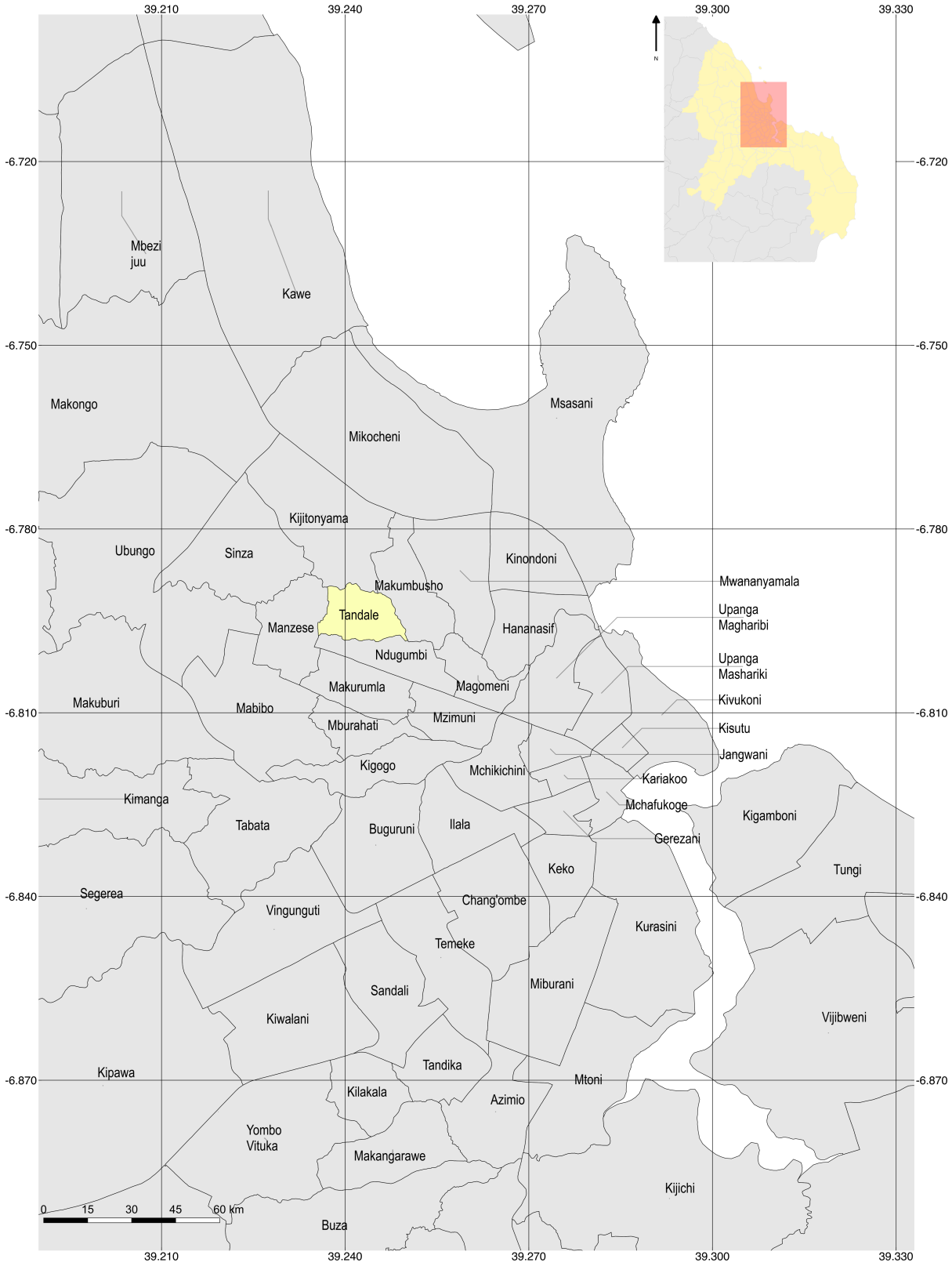



Figure 1.1: Location of Tandale in Downtown Dar es Salaam

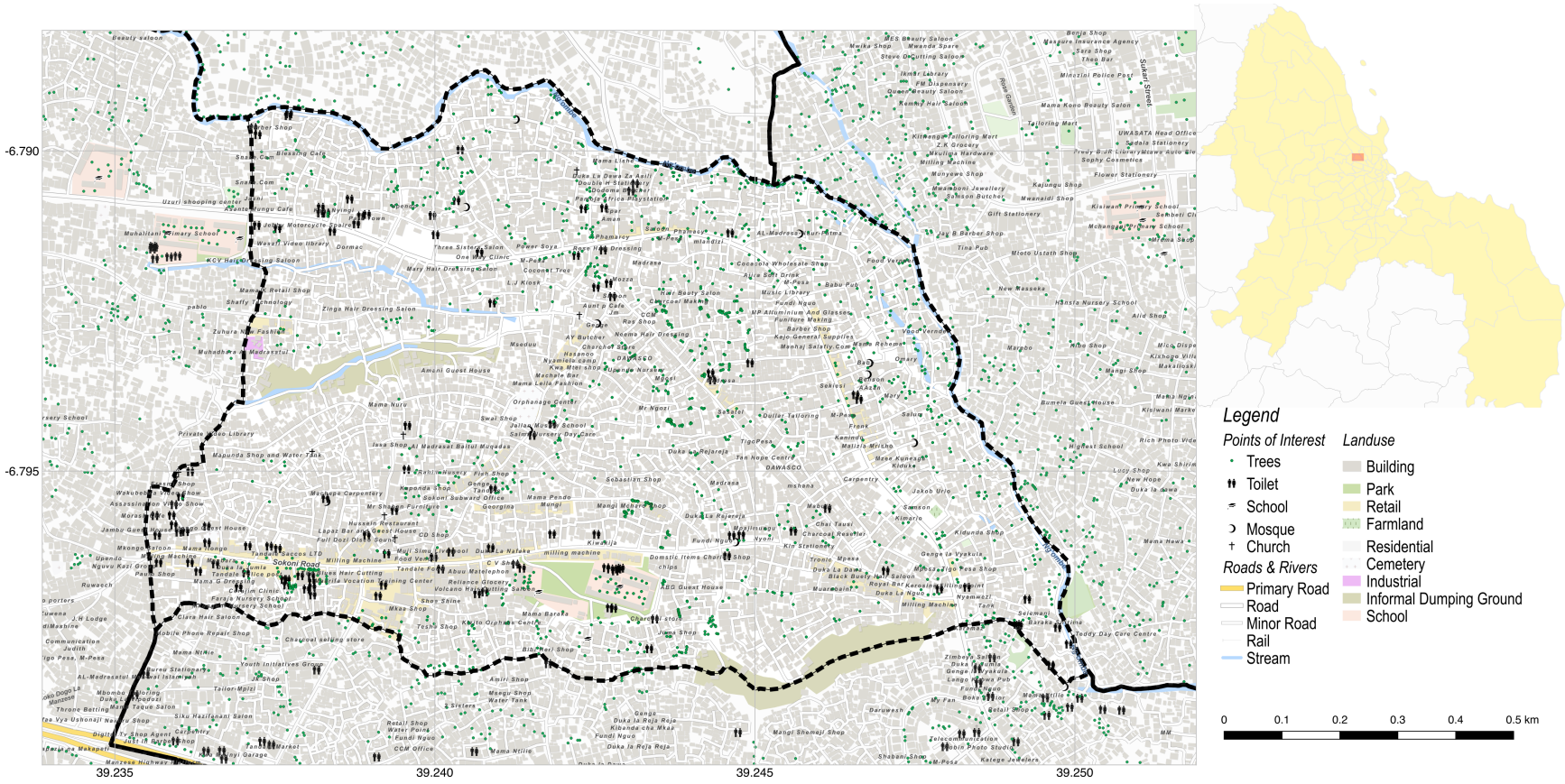



Figure 1.2: Tandale in OpenStreetMap, August 2015

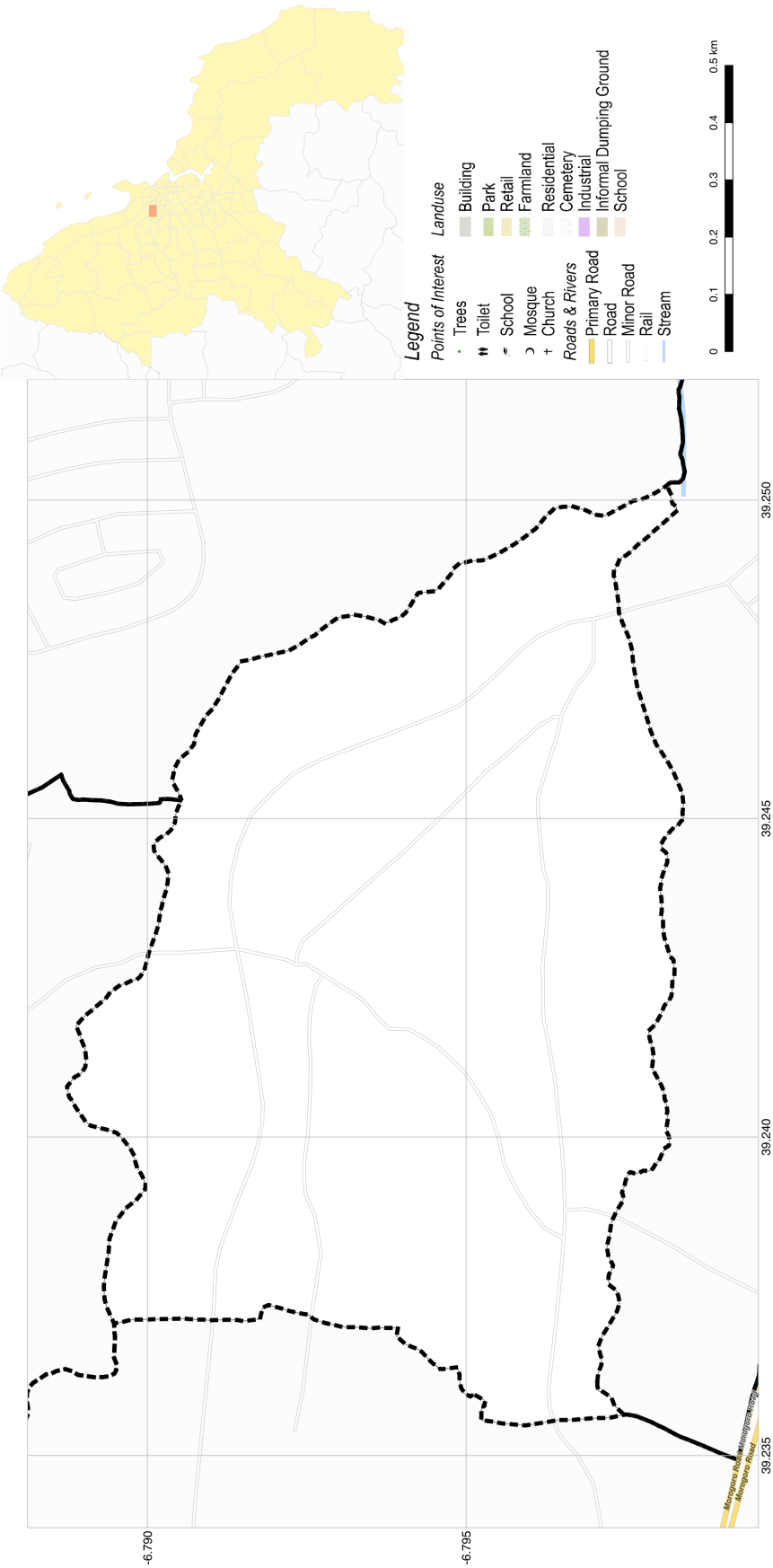



Figure 1.3: Tandale using OpenStreetMap Data, August 10th 2011

Pourabdollah et al. (2013), Zielstra and Zipf (2010) and many others. In particular, one form this has taken is to compare OpenStreetMap, which presents itself as a "wiki for maps", with data from a NMA or other data provider. It is important to note that while OSM is mainly VGI, VGI is not directly equivalent to OSM. Other forms of VGI exist, such as Google Map Maker, a proprietary system analogous to OSM but less popular and ubiquitous with the additional caveat that the data is not openly or publicly accessible outside of Google's suite of mapping tools. Primarily the analysis has focused on topographic comparisons, whereas Mooney and Corcoran (2011) have suggested a further line of inquiry looking at non-topographic quality attributes like lineage and metadata. Here some of the research has focused on internal logical consistency of the OSM data (e.g. looking at the change history of features) and quality attribution rules as demonstrated in Pourabdollah et al. (2013).

Comparisons with external data have generally been predicated on the assumption that the authoritative provider's data is of sufficient quality to be considered definitive. This means that when performing the comparison, the data provider's data is considered to be of such a high degree of accuracy that no account is taken of possible inaccuracies. For example, no error band is considered around the data provider's geometries. Across the developing world, either NMAs, or other commercial providers, do not exist or they have little or no data coverage. Community mapping is proposed to fill this gap, but this requires a thorough assessment of the quality of data collected this way. Due to the absence of comparative data this calls for a mixed-methods approach of comparative analysis and intrinsic analysis Barron et al. (2013). Ultimately, the aim should be to have a process that creates good quality data, negating the need for post-hoc quality assessment. This would be desirable, as collecting VGI in IDCs require human resources, money and time which are not as readily available resources in IDCs. The problem is compounded due to the importance of the data being collected.

Conducting quantitative analysis of VGI data can only provide a post-hoc understanding of the data: to have a complete picture a qualitative analysis is needed to understand the process of collection. This is expanded by Parker et al. (2010) in investigating the motivations and characteristics of the producers of VGI data. Understanding VGI is one component of this thesis, it being complementary to exploring the current meaning and use of community mapping. The term community mapping predates VGI and is explored in depth in Chapter 2. Broadly, it was coined by Aberley (1993) and expanded upon by Parker (2006) in mapping green space in Portland, Oregon, USA and in Perkins (2007) using UK cycling maps. The literature pertaining to community mapping and examples of its use will be expanded in the literature review of Chapter 2. Community mapping projects prior to 2010 were mainly focused in IACs, now community mapping projects are underway across the world, in Kenya, Indonesia and Tanzania (Crowley (2014)) among other places.

Community mapping is the combination of participatory mapping with a wider community engagement. Within IDCs this is within the broad aim of making invisible communities vis-

ible to a wider global audience . Hagen (2011) considers the impact of community mapping from a media perspective, noting that it "empowers communities, with little comment to the by-product of the geospatial data produced"; as Chapter 2 will demonstrate. At first glance the data produced from typical community mapping consists of roads and pathways; however, its depth and richness becomes apparent under closer inspection. Within Tanzania, this depth of data can include geographic features like water taps, toilets, pharmacies, land use, building outlines among many other geographic features. In Chapter 4, data from a community mapping project in Tanzania is analysed both in terms of its own intrinsic characteristics and in comparison with a government-released dataset along with its methodology of production to further define community mapping within the VGI landscape. This is one of the first tests of geospatial quality of data in an IDC in Africa is conducted within this thesis, contributing both novelty and timeliness mirroring the quantitive quality work of Koukoletsos (2012) in Haiti and the process of participatory mapping by Gerlach (2015) in Lima.

OpenStreetMap has been the platform of choice for open geospatial data in the developing world. This in part is due to its de facto status as the main platform for crowdsourced topographic geospatial data. The question of available data is further complicated by the lack of open data movements in IDCs, something Davies and Bawa (2012) explores by comparing the progress of open data programs in 17 IDCs. Open data programs are a key provider of public data in IACs, but in IDCs programs are either beginning or do not exist. As a consequence, access to authoritative data can be problematic, if it exists at all. This is compounded by spatial data historically being expensive in terms of cost and labour to produce, maintain and disseminate.

As the Literature Review of Chapter 2 will discuss, there are many VGI activities on going across the world. But, research into these activities have focused on IACs. This thesis argues that this is a challenge of community participation[1] . By comparing VGI quality of Yaoundé, Cameroon, Barron et al. (2013) propose a framework for intrinsic quality assessment, as opposed to Haklay (2010b) comparative method; thus enabling the investigation of VGI quality when there is no conventional comparative dataset. With the case of Yaoundé, Cameroon, they find that the majority of contributions were conducted through imports and aerial mapping, contributed by outsiders, not by an engaged local community, reinforcing Haklay's view of OSM not being an inclusive project. Lack of knowledge and access to data, tools and methodologies is indicative of limited institutional capacity, the creation of groups that include citizens and government can lead to improved developmental outcomes in IDCs.

[1]Not all communities are equal. Haklay (2010b), in discussing the quality of OSM as a predicate for evaluating VGI generally, compared the state of VGI across the UK against a conventional source states: *"OSM is not an inclusive project, shunning socially marginal places (and thus people). While OSM contributors are assisting in disaster relief and humanitarian aid (Maron (2007)), the evidence from the dataset is that the concept of 'charity begins at home' has not been adopted yet - and thus OSM is failing to provide a free alternative to commercial products where it is needed most"*. This is discussed in Chapter 2 specifically with regard to methods of typifying public participation.

## 1.4 Thesis Motivation

Each country and its cities are unique: all countries and cities need geospatial data to provide public services for their citizens. This is particularly the case in the developing world. In Industrially Advanced Countries (IACs) such data is generally collected by National Mapping Agencies, with associated policy frameworks, institutional governance and legislation that supports the collection of authoritative information and enable the provision of *reference datasets* (i.e. data sets collected for official purposes).

Tanzania (located in Figures 1.4 and 1.5) is representative of so many fast growing IDCs across Sub-Saharan Africa, in that there are many challenges that prevent development towards IAC status. In the 2014 United National Human Development Report, Tanzania stands 159 out of 187 in the Human Development Index (Malik (2014)), a multivariate index amalgamating life expectancy, education level and gross national income among other factors. Urban population, infrastructure and general wellbeing are vulnerable to many factors, with poorly maintained transportation infrastructure and non-existent public services (Joshi and Moore (2004)) combined with climate variability and future climate change causing the potential for severe weather events which have and will paralyse its urban centres, destroying infrastructure and causing loss of life UN (2014), Davies (2015), as part evidenced by the author in Figure 1.6 in its primary city, Dar es Salaam (Figure 1.7).

As of 2014, Dar es Salaam is the fastest growing city in Africa (ADB (2014)) and one of the fastest growing cities in the world, where a continuously and rapidly expanding population of over 4.3 million residents inhabit a city planned for 300,000 (Calas (2010)). Over 70% of these residents live in unplanned, informal settlements Baker (2011)).

This pace of growth has stretched the already limited capacity of statistical and data-providing agencies. For example, in 2011, a global task force of Mayors composed of the Mayors of Dar es Salaam, Jakarta, Mexico City and São Paulo supported by the World Bank and the Tanzanian National Bureau of Statistics, forecast that Dar es Salaam's population was 2.5 million and would grow to up to 5 million inhabitants by 2020 (Baker (2011)). This was significantly revised upwards a year later for the 2012 census which registered 4,364,541 inhabitants. Dar es Salaam will only continue to grow even faster due to Tanzania's stability and consistent economic growth levels, ultimately becoming the de-facto regional hub. Conversely, the current approach to gathering Geographic Information is evidently limited.


Figure 1.4: Africa and Tanzania

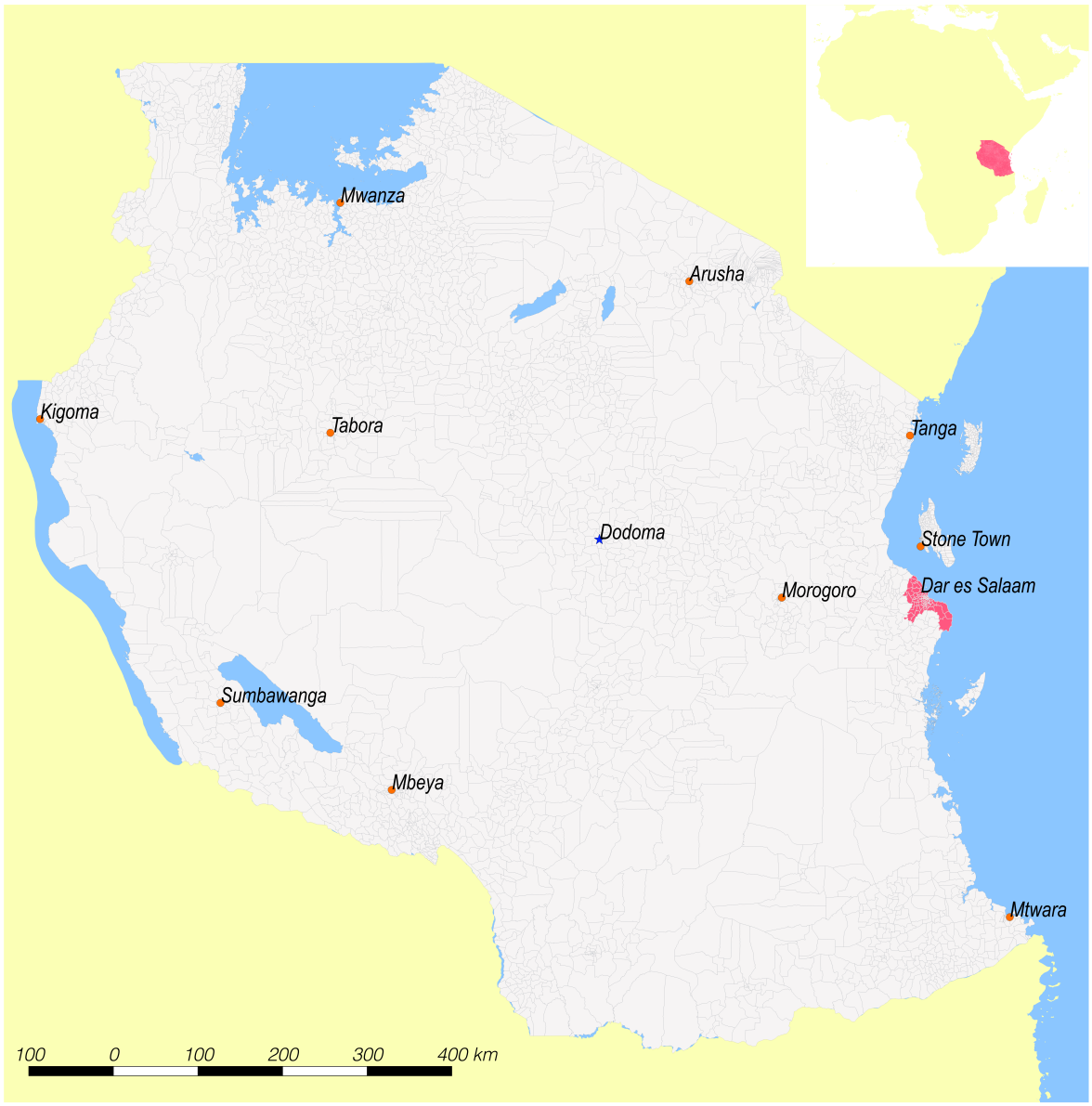



Figure 1.5: Tanzania

## 1.5 Data and Maps in Dar es Salaam

The Baker (2011) report on the state of urbanisation in Dar es Salaam noted: *"accessing data, maps, and climate projections was problematic. Information is scattered across many different agencies, departments, organizations, and research institutions, with some reluctant to share data"*(p12). In Tanzania, the responsibility of providing geospatial data is roughly split between:

1. PMO-RALG (Prime Minster's Office - Regional Administration and Local Government);
2. Ministry of Lands - Mapping and Survey Division;

Figure 1.6: Damage of Flooding in Dar es Salaam

3. National Bureau of Statistics;
4. Other ministries and agencies having responsibly for certain datasets, such as flood inundations maps at the Prime Minister's Office - Disaster Management Department.

In the author's experience, echoed by Baker (2011), there is little to no coordination between these ministries with competent technical staff overloaded and others not able to contribute to a level required by the challenged faced by the city. 30% of the city is formally planned, leaving 70% unplanned remainder being planned using little or no data that would locate amenities, population density or existing infrastructure, with data that is available difficult to access.

At the start of this thesis parts of Dar es Salaam appeared as a blank spot on many maps with demonstrably sparse data, as evidenced in Figures 1.8, 1.9 and 1.10 and is further discussed in Chapter 4.

Figure 1.8 shows the ward of Tandale, one of the most densely populated wards of Dar es Salaam (and a focus ward for this thesis). This is on the VGI repository, OpenStreetMap, however, the situation is similar with other map providers. Figures 1.9 and 1.10 shows the situation on Google Maps and Here Maps respectively as of the submission of this thesis in late 2015.

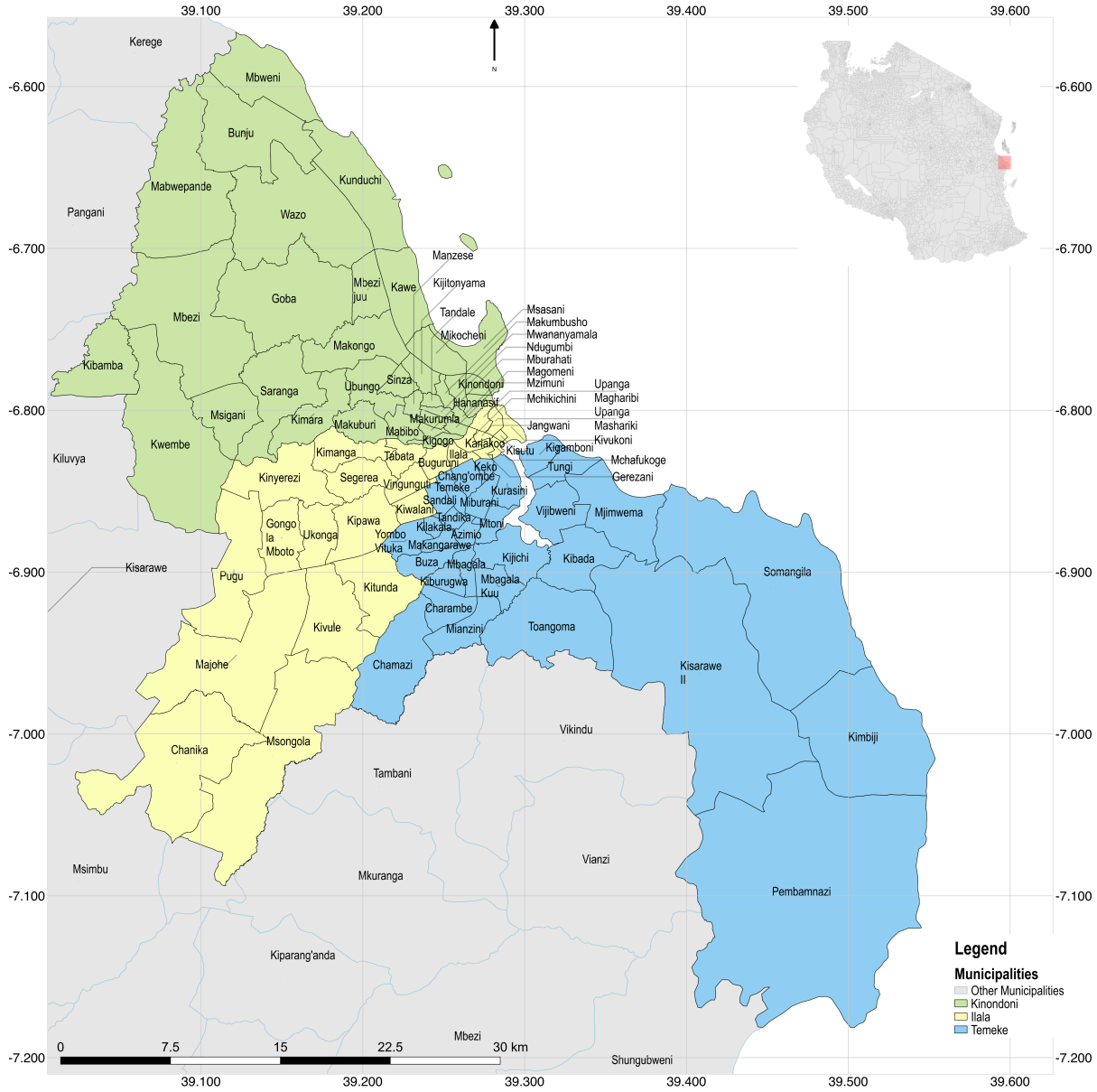



Figure 1.7: Administrative wards of Dar es Salaam

Notably, the geocoder for Google Maps locates Tandale in Kijitonyama ward, indicating poor data management of administrative boundaries. Within the feature set of the maps, there is little thematic detail barring roads. There are two ways that this scarcity of data could be alleviated: through conventional or crowdsourced mapping. Commonly it would need some commercial benefit for commercial conventional mapping providers, such as Google and HERE to produce maps to the same detail that they provide in IACs, but this seems not to have been identified so far. Within the the realm of conventional mapping, this leaves the option of the government providing maps; however, as previously noted by Baker (2011), the capacity and coordination of the government's mapping would have to be improved. In the future, two programs could potentially could alleviate this situation: Open Data and the Tanzanian National Spatial Data Infrastructure:


Figure 1.8: Tandale in OSM, circa 2011

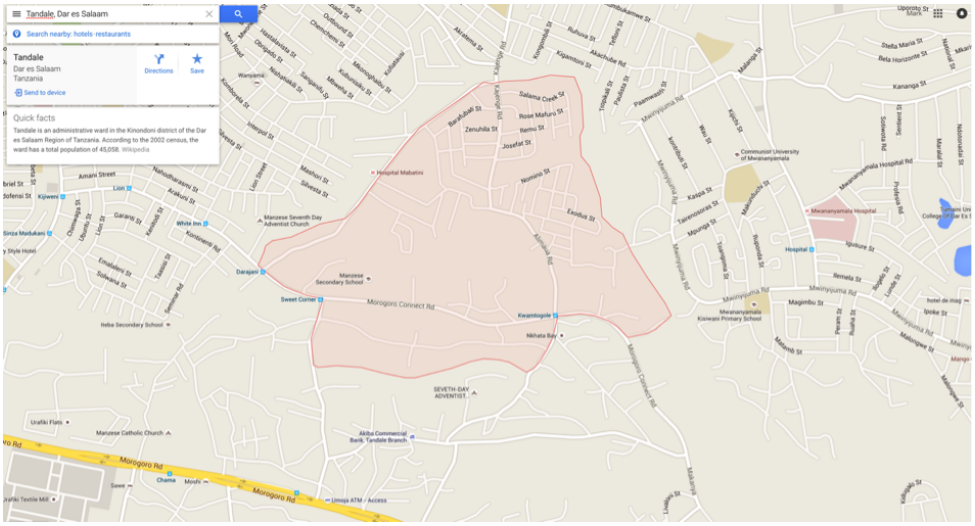



Figure 1.9: Tandale in Google Maps, circa 2015

- Open Data, being a policy instrument that 'opens' up data - making it available to all, freely at no cost with the intention *"to make the Government business more open to its citizens hence improve public service delivery, government responsiveness, combating corruption and building greater trust"* OGP (2015). This is a good statement in priciple, however, according to the Open Government Partnership Action Plan Tanzania (2015), there is currently no plan for the release of map information, barring cadastral and land use information (which is incredibly important in its own right), in part due to the inability to release non-digitised maps to the public.
- Clinton (1994) defines National Spatial Data Infrastructure (NSDI) as *"the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data"* Lugoe and Yanda (2007) provide a policy note for an NSDI that would facilitate the sharing of spatial data across Tanzania and its

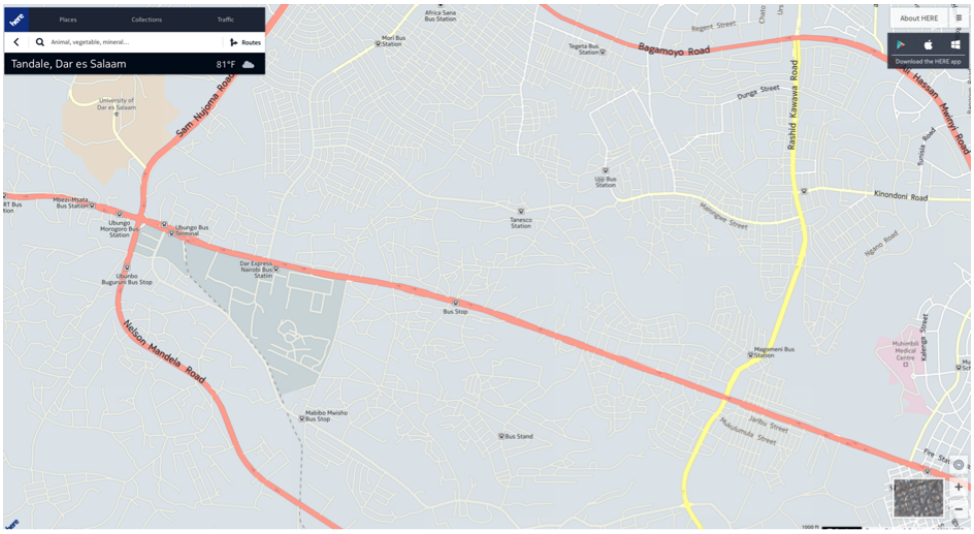



Figure 1.10: Tandale in HERE Maps, circa 2015

institutions, through the "National Steering Committee on NSDI (SC-NSDI)", though according to Larsen (2014) this initiative failed due to lack of donor funding. From the author's personal experience, the National Bureau of Statistics, the Ministry of Lands and other aforementioned ministries as of late-2014 have re-formed an NSDI working group, but it will be a few years before this could lead to the sharing and utilisation of geospatial data across government departments, ultimately leading to better decision making.

Both of the aforementioned programmes will go some way to improving the situation of data and data access, leading to an improvement in the environment through data-driven decisions. For instance, helping to understand where to build infrastructure X to alleviate flooding in Y. This could be done through making the data accessible and building capacity to those in the community and government who have the ability to effect change and who make decisions without that data currently. But first, understanding the nature of community mapping as a system is essential.

## 1.6 Socio-Technical Systems

Through taking a socio-technical systems approach, the opportunity exists to move beyond *descriptions* of community mapping as per Hagen (2009, 2011). In doing so, the opportunity exists to examine how constraints on participation to community mapping can occur, while examining the design space from a socio-technical perspective. This enables concepts generation that move past discussions on VGS, HSW and LBS towards to utilisation of VGI in an IDC.

This is enabled through Cognitive Work Analysis, that allows for Rasmussen et al. (1994a) states *design should define for the actors a space bounded by the goal and resource constraints"* This is appropriate given challenges of IDC environments as discussed in section 1.4.

## 1.7 Research Objectives

While fully explored in the following chapter in reviewing the literature, there is clearly a gap of knowledge between understanding how communities create VGI in IDCs whencompared to the body of research on VGI and community mapping in IACs. Accordingly, the research question of this thesis is:

*What are the differences between community mapping in IDCs and IACs?*

This will be achieved through cases studies of community mapping in Tanzania, ultimately creating a conceptual framework of community in IDCs. To research and validate this conceptual framework, this thesis is guided by a series of research objectives, namely:

**Research Objective 1** Examine the characteristics of VGI quality in IDCs;
**Research Objective 2** Examine the praxis and characteristics of community mapping in IDCs;
**Research Objective 3** Determine the constraints of the design space of community mapping in IDCs;

These objectives allow for a thorough investigation of the theories, concepts and practices of community mapping, whilst suitably defining the scope and methods deployed later by this thesis.

## 1.8 Motivations of the Author

The previous sections aimed to take an objective view on research area. As such, it is useful to understand the personal orientation of the author of this thesis. My orientation draws heavily on my own experience working as an international development professional, focused on geospatial and ICT policy issues, mostly in East Africa, working simultaneously with government officials and the citizens that they serve, primarily with the World Bank, but also with other development agencies.

This experience has been simultaneously furthered by the research conducted within the empirical chapters of this thesis, leading to their transformation from concepts and theories to implementation. For example, from volunteering with Map Kibera in 2011, through to designing and leading the Ramani Huria community mapping project in 2014. These experiences

have directly led to the generation of new theories and concepts presented in this thesis. This process has been at times fraught and stressful, at others privileged and rewarding, combined with operating in an environment and culture which was not my own. My culture is one of Western European ideals, where access to public services such as healthcare and water is beyond question, in the places where I now work the values and interests of these countries completely differ to my own. This necessitates a truly open mind to adapt and integrate within the local cultural fabric, otherwise, issues of ethnocentrism will arise.

Balancing the needs and drive to conduct novel ethical research while retaining professional ethical standards is not a novel subject for discussion. The approach of the researcher seeking *cognition in the wild* has a rich history within understanding complex socio-technical systems as evidenced by Hutchins (1995) examination of a US Navy Navigating Officer and Aoki (2007) investigations into the social interactions around command and control situations on ships. Ensuring that there is as little bias as possible is important, but as is the recognition that the situation for researching complex systems like community mapping would be impossible otherwise.

Blatantly, this professional inclination and the subsequent opportunities such as repeated access to the research environment have been essential in conducting the subsequent empirical chapters. Prior to this professional experience, my undergraduate and postgraduate research combined the application of VGI in the real world and the deployment of novel technologies for conservation in Kenya respectively. Therefore, it should be recognised this work does not originate from a neutral stance, but a stance that believes that humanity has shared values of community, freedom and agency for all, especially for those in less fortunate in our global society. In this, this thesis advocates Articles 1 and 3 of the United Nations Universal Declaration of Human Rights United Nations (1948), namely:

1. All human beings are born free and equal in dignity and rights. They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood.
2. Everyone has the right to life, liberty and security of person.

This declaration while presenting a very altruistic viewpoint on human society additionally provides ethical justification for developing a formative design for community mapping, while supporting my own interests in enfranchising communities and supporting the mission of human development.

## 1.9 Thesis Contributions

While Dar es Salaam is growing quickly, it is not alone. Sub Saharan African cities like Nairobi, Lagos and Addis Ababa are equally experiencing this rapid pace of urbanisation. Rapid urbani-

sation and population growth, is one of the challenges that countries need to solve. Traditional methods of Geospatial Information collection, through National Mapping Agencies in IDCs, do not provide the *completeness* or *consistency* of Geospatial Information that IDCs require. This thesis argues that Volunteered Geographic Information (VGI), using a new protocol of collection - Community Mapping - could meet this gap. As such, the protocol of community mapping is examined through case studies (in sections 5.4 and 6.3) in a community in Dar es Salaam, leading to the construction of a Cognitive Work Analysis - a methodology to construct socio-technical systems to explore the design space of community mapping (in section 6.4).

In the future new policy instruments could be useful for providing/liberating data that can be used for decision makers in Tanzania and IDCs with a similar capacity compared to IACs. Potentially, institutions such as UNGGIM will help provide the framework for countries to build upon. But, due to the aforementioned issues of rapid urbanization and lack of public service provision, accurate, up-to-date maps showing the urban landscape of amenities, roads and other features are needed now. It is at this crux, where this thesis aims to make its contribution.

In summary, the contribution of the thesis is as follows:

- Interrogation of the quality of VGI generated with community mapping;
- A conceptual framework of community mapping in IDCs, delineating between characteristics of IDCs and IACs;
- Describing the socio-technical environment of community mapping, demonstrating how constraints can be identified in public service provision;
- Situating community mapping, identifying paricipant roles, characteristics and tasks;
- Discussion on how data from community mapping can be combined with other forms of data to create novel insights in lieu of traditional demographic data.

## 1.10 Thesis Structure

The remainder of this thesis is structured as follows:
**Chapter 2** reviews the relevant literature, such as volunteered geographic information; spatial data quality and human factors methodologies, including cognitive work analysis and further defines the problem statement that this thesis addresses, expanding upon the rationale for the aforementioned problem statement, research question, aims and objectives.
**Chapter 3** describes the methodologies and processes of CWA.
**Chapter 4** is a scoping study of the quality of community mapping created Geospatial Information in the ward of Tandale.

**Chapter 5** investigates community mapping in Tanzania, specifically presenting a case study of the Tandale community mapping project through a mixed methods approach of observer-as-a-participant and semi-structured interviews with community mapping participants.
**Chapter 6** develops a socio-technical framework of the community mapping space using the techniques of cognitive work analysis. This framework is validated by a mixed methods approach of observer-as-a-participant observation and semi-structured interviews with community mapping participants in Tandale, Tanzania.
**Chapter 7** discusses, compares and contrasts key findings from the research conducted for this thesis, such as theories of community mapping in developing countries and CWA as a tool to describe the generation of spatial data. The original contributions to the domain of knowledge are also presented and examined.
**Chapter 8** provides concluding remarks and proposes future research directions, against which work can be evaluated and enhanced.
The **Appendix** contains research material from the various interviews conducted as part of this thesis and an expansion of the Cognitive Work Analysis detailed in Chapter 6.

Figure 1.11 shows the main structure of the thesis.

## 1.11 Chapter Summary

This chapter has laid the foundations for this thesis by introducing the background, motivation and origins of this program of research. The aims and objectives of the research have been described. The structure of the various analyses and case studies are illustrated using a research overview diagram in Figure 1.11.

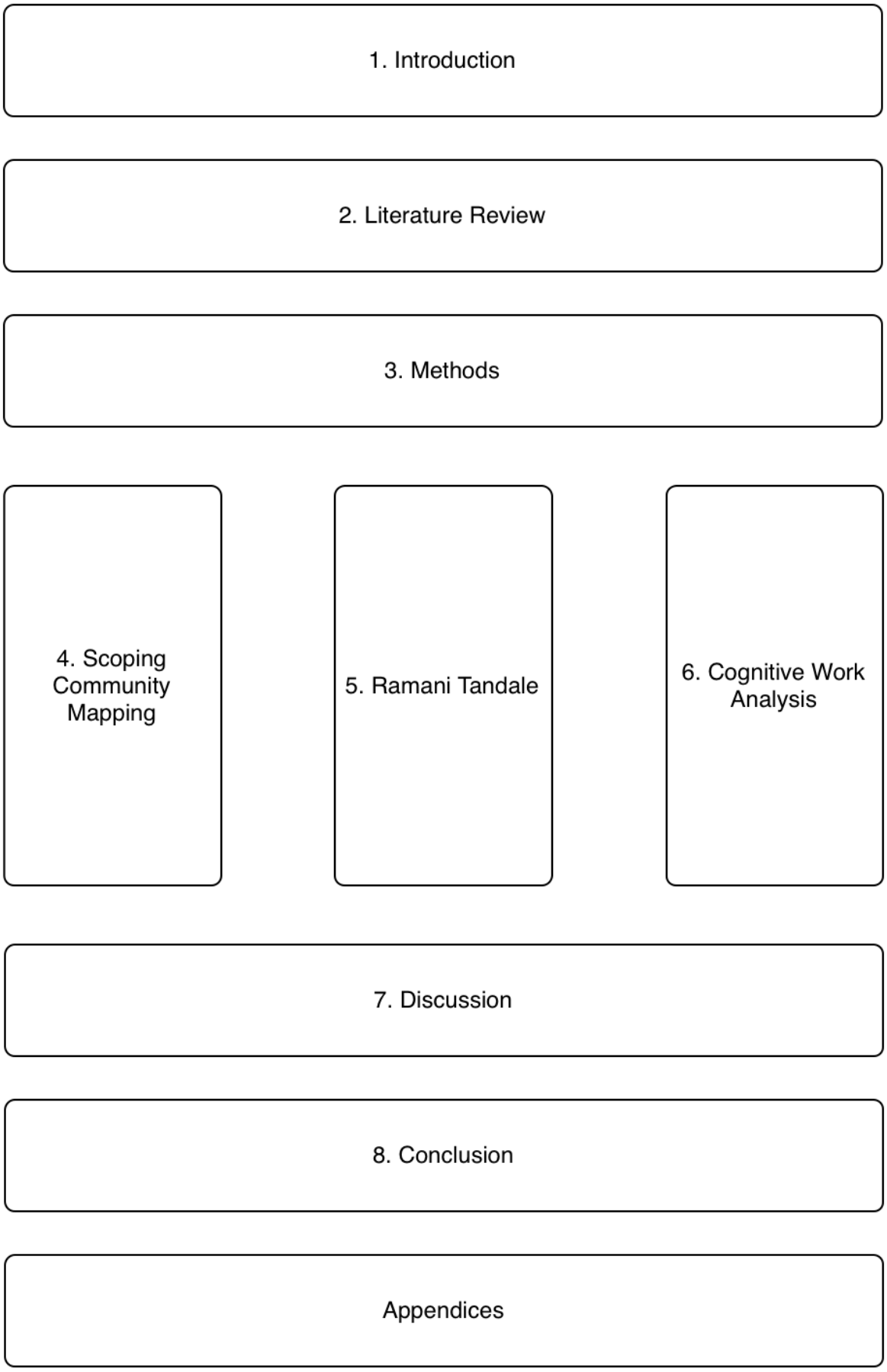



Figure 1.11: Thesis Diagram

# Chapter 2

# Literature Review

## 2.1 Introduction

This chapter provides a review of literature that is relevant to this thesis. This focuses on the intersection between the domains of Geospatial Information Science (GIScience) Volunteered Geographic Information (VGI) and community mapping in Industrially Developing Countries (IDCs), in part through contrasting literature considering Industrially Advanced Countries (IACs). Literature is reviewed and gaps identified, specifically gaps in academic literature in VGI when contrasted with emergent phenomena of community mapping. In this analysis, concepts such as citizen participation, socio-technical systems and crowdsourcing are also introduced and discussed.

## 2.2 Maps

Maps are important. Harley (1989) succinctly illustrates the power and importance of maps as thus:

> *"Power is exercised with cartography. Monarchs, ministers, state institutions, the Church, have all initiated programs of mapping for their own ends. In modern Western society maps quickly became crucial to the maintenance of state power to its boundaries, to its commerce, to its internal administration, to control of populations, and to its military strength. Mapping soon became the business of the state: cartography is early nationalised. The state guards its knowledge carefully: maps have been universally censored, kept secret and falsified... A mapless society, though we may take the map for granted, would now be politically unimaginable. All this is power with the*

> *help of maps. It is an external power, often centralised and exercised bureaucratically, imposed from above, and manifest in particular acts or phases of deliberate policy."*

Alas, as Baker (2011) discusses with respect to mapping in IDCs, maps and the geographic data used to create those maps is either hard to find, or non-existent in IDCs, effectively creating *mapless societies* across the world. This is a severe barrier to development, impacting communities in a multitude of differing ways, from poor public service provision to land rights disputes. Reasons for this scarcity of data include poor institutional capacity in governance and lack of funds (McCall (2003) but also, as Peluso (1995) discusses in agreement with Harley (1989), maps are used as tools of power and so at times withheld. Sen et al. (2003) discusses the effect that this has on informal communities in IDCs, specifically a case in Pune, India. This discusses how the Pune Municipal Corporation declares certain areas "slums" whereas other areas, with arguably the same characteristics and basic needs are not considered eligible for basic service provision[1].

In response to this, Peluso (1995) contends that the methods of creating maps can be used by authorities as tools of power, defining *counter mapping* as a method where local communities use mapping methods and tools to *counter* the lack of accessible maps leading *"to representations of themselves and their claims to resources"*, through a case study of indigenous communities in forest communities in Indonesia. More recently, mapping projects in IDCs have been enabled through technology, this is exemplified by projects such as Map Kibera, based in the Kibera informal area, Nairobi, Kenya.

Hagen (2009) discusses that in Kibera formal maps were inaccessible, so by using OpenStreetMap, Kibera was mapped using consumer grade GPS tools *by* the community of Kibera. What was mapped was the choice of the mapper: *"The mappers were allowed to choose what features were most important to collect, and agreed to try for every single water point, toilet, clinic, pharmacy, school, church, mosque, and NGO office, plus anything else at their discretion. They painstakingly uploaded the data using the Java OpenStreetMap editing software, overcoming a substantial lack of computer experience"*. The maps and the data behind them were then made freely available on OSM. These maps were in theory accessible not just to those community members in Kibera, but also to the wider world, though there is an extent to which online maps are inaccessible in technologically challenging environments such as Kibera. In Kibera, these maps had the effect of facilitating and strengthening community interactions and discussion around community driven media and journalism, as investigated by Ekdale (2014) and other activities, such as public service delivery and security.

[1]This thesis advocates for a neutral stance when considering public service provision in IDCs; while issues such as governance and developmental capacity will be discussed, wholly addressing this challenge is beyond the scope of this thesis and subject to the UN's Sustainable Development Goals

### 2.2.1 GIScience

Map Kibera is indicative of a much broader shift within the realm of GIScience. Considering the progression of GIScience, that geography and location have become ubiquitous tools used by the masses (citing tools such as Google Earth and Bing Maps) they claim that in a few years, accuracy of less than 100m will be available through positioning technology embedded into mobile phones; this is detailed by Ramm et al. (2011) in the following year as being to a 5m degree of accuracy, indicative of the pace of technological advancement, in a relatively small time period.

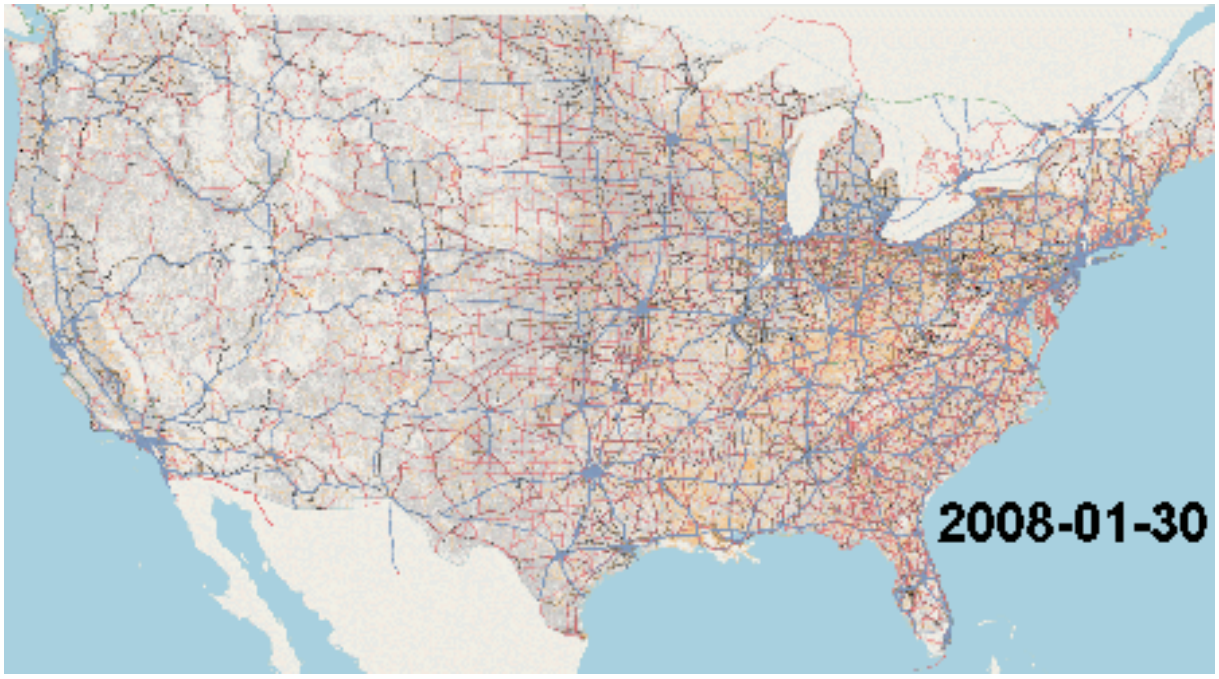
This has been mirrored by the emergence of new theories and methodologies in the realm of GIScience, such as Neogeography (Turner (2006)); Volunteered Geographic Information (Goodchild (2007)) and Public Participatory GIS (Sieber (2006)). Parallel to this tools such as OSM, Ushahidi (Okolloh (2009)) have subsequently leveraged these methods and theories, taking them outside of scholarly research and applying them in the real world. This shift to practice from theory has enabled the democratisation of cartography. OSM for instance, from humble beginnings as the side project of Steve Coast in 2004, has since grown to have a user-base of over 2 million registered contributors[2]. Haklay and Weber (2008) chart the technical progress and start of OSM as a tipping point from where the creation of maps moved from being the preserve of trained and skilled cartographers to an activity that *volunteers* can undertake, leading to a democratisation of cartography. Some of these terms are loaded, as discussed later by Haklay (2013b) and in this thesis.

### 2.2.2 OpenStreetMap (OSM)

As the majority of data used in the case studies of this thesis is based on OpenStreetMap, a detailed understanding of OSM is necessary. Haklay and Weber (2008) and Goodchild (2007) to varying degrees describe the OpenStreetMap project, founded to create a *"free and open map of the world"*. This vision is subsequently realised and is expanded by Ramm et al. (2011) in describing the scale of OSM, as a global repository of accessible Geographic Data, also discussing the tools used to create data in OSM. Haklay and Weber discuss the collaborative nature of OSM and the early approach of mapping of the Isle of Wight from May 2006: *"More than 30 participants from Europe spent two days driving, cycling, and wandering around the island with GPS receivers to collect a complete coverage of roads and footpaths. After collecting the individual contributions, processing them, and uploading the data, a practically complete map of the island emerged"*.

[2]Though the number of contributions and frequency is subject of discussion Napolitano and Mooney (2011); Mooney et al. (2011)


(a) Before import




(b) Post TIGER import

Figure 2.1: Data coverage of OSM in the USA before and after TIGER import

Contrasting with Haklay and Weber's collaborative collocated approach, Zielstra et al. (2013) discuss the effect of imports in the USA. In 2007/2008 data from the US Census Bureau was imported into OSM, this had the effect of transforming data coverage of OSM which, at the time was *"sparse"* to effectively full coverage of the 50 states of mainland USA; Figures 2.1a and 2.1b from OpenStreetMap (2012) illustrate this progression. The process of importing such data demonstrates how open data and accessibility to previously inaccessible civic data can support and change data projects like OSM. Imports have since taken place in France, Estonia and the Netherlands (Mooney and Corcoran (2012)) and are in progress in other countries. Though, as Ramm et al. (2011) note there are tensions within contributors to OSM and as Zielstra et al. (2013) discuss, there can be issues with the quality of the import. The combination of these two approaches, namely imports and localised contributions, raises further issues such as credibility and authority that are relevant in the context of OSM and VGI generally.

OSM is not the sole repository for VGI data, though it is one of the most common. OSM also differs from others such as Google Map Maker (GMM) in that it is freely available under an open licence. Chilton (2009) discusses this concept with regard to GMM and other data providers, noting that data is volunteered in the same manner as OSM, the rights of the data subsequently become the property of the company not the individual who had collected it. The nature of who owns the data is important as it raises questions about the enfranchisement and purpose of the community collecting the data. This is discussed in further detail in section 2.4 in discussing the nature of participation, from full participation and community control to enforced participatory and a lack of community control.

### 2.2.3 Volunteered Geographic Information

The phrase Volunteered Geographic Information (VGI) was coined by Goodchild (2007) to reflect the emergence of citizen generated geographic content. VGI has become a key topic of interest due to numerous factors, such as the relative accessibility and ubiquity of technology enabling the capturing of location. This section discusses VGI's characteristics, offering perspectives on data quality and its credibility and relevance to the IDC context.

The rise of VGI mirrors the rise of Geographic Information generally. Haklay and Skarlatidou (2010); Brown et al. (2013) discuss how this has moved from being in the realm of the expert, to a wider demographic with a less *expert* view of GI. National Mapping Agencies (NMA) such as the UK's Ordnance Survey releasing datasets, access to Geographic Information, and the rise of Open Source and freely available tools such as QGIS (Graser et al. (2014)) have all led to a shattering of the assumption that underlying data produced by National Mapping Agencies (NMA) will be used solely by professionals[3].

[3] The derived maps from this data obviously are to be consumed by the general populous.

Turner (2006) defines this as *"**Neogeography**...people using and creating their own maps, on their own terms and by combining elements of an existing toolset. Neogeography is about sharing location information with friends and visitors, helping shape context, and conveying understanding through knowledge of place"*. As such, in both VGI and Neogeography, the key factor is the *volunteer* geographer, as opposed to the expert cartographers and production of maps as discussed previously by Harley (1989) and Peluso (1995); they *participate* as part of a public process as indicated by the participation demonstrated by Hagen (2009), Sen et al. (2003) and others.

## 2.3 Characteristics of VGI

VGI has led to a rise in researchers looking to understand its characteristics, from Gouveia and Fonseca (2008) discussing approaches of data collection, presentation, validation, and community building with reference to VGI supporting environmental monitoring, to Parker et al. (2010) investigating the characteristics of VGI stakeholders. This section examines the characteristics of VGI.

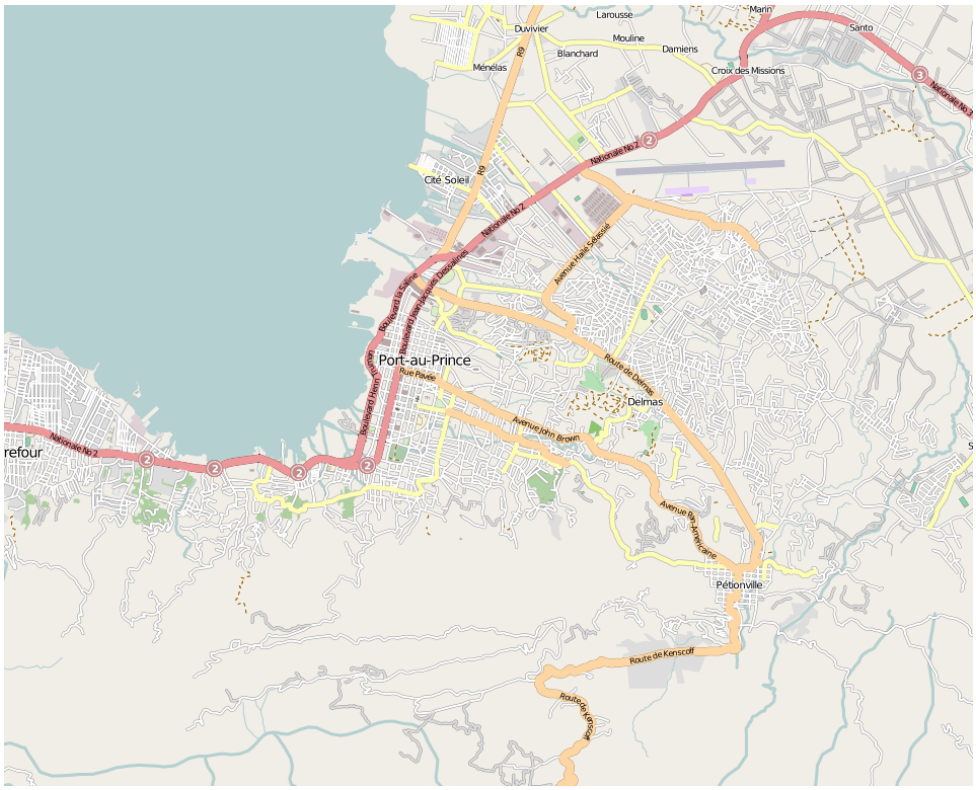
### 2.3.1 Approaches to Collecting VGI in IDCs

As previously discussed in section 2.2.2 there are multiple methods of collecting VGI. Dobson (2013) and Harvey (2013) discuss these concepts further, presenting the distinction between *active* and *passive* modes of VGI contribution. Passive contribution of VGI focuses around data gathered automatically, without the direct input of the user. This raises ethical and legal implications of consent and questions whether information is truly *volunteered*. With respect to the scope of this thesis solely active collection of VGI is considered.

Port au Prince, the capital of Haiti is similar to many IDC capital cities, with a combination of high urban density and rapid, unchecked population growth and informal settlements. Prior to a catastrophic earthquake on the 12th of January 2010, over 2.5 million people called Port au Prince home. Bilham (2010) discusses the immediate impacts of the earthquake, with an official death toll of 230,000 and roughly 1.5 million residents (over 50% of the city) homeless[4]. The earthquake response was further bolstered by the the advent of freely available satellite imagery. Now a global community was able to digitise this raster data and create geographic data to support the earthquake response. The vectorisation of raster data is common place for GI professionals but a combination of factors, such as OSM, more available imagery and a global network of volunteers presented a revolutionary moment in the hours prior to the Haitian Earthquake in 2010.

[4]Human Rights Watch (2011) discusses the after effects of the earthquake further, noting that statistics while being official are vague due to the lack of precision of official statistics prior to the earthquake


(a) Before earthquake




(b) Post earthquake

Figure 2.2: OSM Before and after Haiti 2010 earthquake

Figure 2.2[5] shows the extent of these volunteer contributions 53 hours after the earthquake. Subsequent work by Haklay (2010a) and Koukoletsos (2012) examine the geospatial quality of these contributions, finding that when compared to other data sources, such as those from the UN Stabilisation Mission for Haiti ("MINUSTAH") and GMM. OSM *"is by far the richest dataset [of] the area"* (Koukoletsos (2012)). However, this volunteered contribution has challenges as noted by Soden and Palen (2014): *"as most of these data were created by digitising satellite imagery, it was primarily composed of the geometry and location of major features only, and lacked significant attribute details such as road names and building uses at that time"*.

The humanitarian response of volunteers creating freely available geographic data proved a watershed moment for VGI. Zook et al. (2010), Norheim-Hagtun and Meier (2010), Meier (2012) and Soden and Palen (2014) frame how the collaborative effort of global communities working rapidly and remote can create maps, since 2010 this approach has replicated for other crises such as Typhoon Yolanda (Westrope et al. (2014); Palen et al. (2015)).

The combination of the approach of Map Kibera (Hagen (2009) and section 2.2) and the approach of the crowd digitising aerial imagery offers an opportunity to resolve the issues identified by Soden and Palen (2014), in that geometric features such as buildings and roads can be mapped using aerial imagery, with thematic data being collected through community mapping. Challenges to this, include finding a willing 'crowd' to digitise aerial imagery (if it is available) and an engaged community to collect data. For those living in places such as Kibera and Tandale, it is not reasonable to assume that community mapping can emerge due to lack of technological access and more basic living concerns of inhabiting informal developments.

### 2.3.2 Authority and Credibility

Concepts such as *authority* and *credibility* are important when applied to VGI, due to the nature of it's production. Goodchild (2008) charts the history of cartography and the emergence of VGI, reinforcing earlier discussions on how technology is breaking down barriers in cartography through *neogeography*, leading to the production of maps being conducted by non-experts. The frame of Neogeography enables non-expert users to not have to make decisions about placement of labels, fonts or projections, as these decisions are made by software. This raises questions of authority and credibility of the resulting data, concepts that would traditionally not be an issue due to the authoritative and credible nature of NMAs.

[5] Each of these images was created by Mikel Maron and are licensed under the Creative Commons 2.0 Generic Licence: https://creativecommons.org/licenses/by/2.0/, the data is licensed ©OpenStreetMap contributors, additionally with permission of Mikel Maron.

#### 2.3.2.1 Credibility

Flanagin and Metzger (2008) presents the credibility of VGI as a multi-faceted concept, considering the origin, believability and quality of data. Zielstra et al. (2013) further extends the notion of quality, discussing the numerous research endeavours into quality (also discussed later in section 2.3.3), where VGI has a higher assessment of quality than the comparative authoritative reference data. Horita et al. (2013) (citing Elwood (2008)) contrasts with this viewpoint stating that *"VGI can be regarded as lacking credibility and reliability because it is produced by non- experts in a context that differs significantly from* ***"structured institution-initiated and expert-driven contexts"***(Elwood (2008)).

This thesis advocates that this is a limiting conclusion. This is reinforced by Flanagin and Metzger (2008) who further examine the potential of credible VGI, citing cases of Citizen Science, loosely defined by Haklay (2013a) as "*scientific activities in which non-professional scientists volunteer to participate in data collection, analysis and dissemination of a scientific project".* Flanagin and Metzger (2008) specifically cite the case of the Audobon bird count where volunteers receive training to ensure validity and reliability of the data they collection. They conclude that this form of VGI is credible by virtue of the training and and education of novices by experts. This mirrors the approach undertaken in Map Kibera and is investigated further by this thesis.

#### 2.3.2.2 Authority

Feldman (2011) questions whether VGI can be authoritative, comparing the characteristics of OSM with Authoritative data from the NMA of the UK, the Ordnance Survey, noting that an authority can at times be wrong, and collects reference data - i.e. collected according to requirements of the authority. In contrast VGI potentially offers more depth, as it is not constrained by a rigid taxonomy of collection, though as demonstrated previously the collection of VGI is not uniform. Haklay (2010b) discusses this challenge further, assessing the relationship between OSM edits and deprivation indices in the UK, finding that bias exists towards not mapping socially marginal places in IACs, necessitating a need for NMAs to continue to provide data in such places.

Within IACs Coote and Rackham (2008) contrast the opportunity posed by VGI and its potential value as being more "up to date" with concerns of:

- *"**Completeness**: the perception that data is universally complete for the area of coverage;*
- ***Consistency**: the lack of fixed specification for capture and encoding, whilst being superficially attractive by giving freedom of expression, will constrain use for analysis;*
- ***Quality Control**: how to assess the 'wisdom of the crowd' and ensure that vandalism, unintentional or otherwise does not undermine users confidence in the product.*

- ***Quality Assurance**: the lack of clear and verifiable statements relating to quality, and the methods used to assess it, will be serious impediments to widespread adoption."*

These factors are echoed by Coleman (2013) in contrasting VGI with "*Authoritative Data*". The term Authoritative Data has been used to describe data produced by professional mapping organisations such as a National Mapping Agencies and/or institutions such as the UN, as well as commercial Geospatial Information providers (Coleman et al. (2009); Goodchild and Glennon (2010); Koukoletsos (2012); Barron et al. (2013)). Within the UK context, Pourabdollah et al. (2013) investigates how OSM can become authoritative, presenting conflation between OpenStreetMap (as VGI) and Ordnance Survey (as Authoritative) data leading to a combined dataset.

In contrast, the situation in IDCs is bleak: due a myriad of other complex factors such as institutional capacity, lack of skills and budget; in some countries, NMAs exist as plaques on doors and budget line items, as opposed to functioning institutions that supply geospatial data and maps to other ministries, agencies and other public bodies. Baker (2011) discusses the challenge of conducting a baseline survey of the urban poor across four IDC cities, Dar es Salaam, Jakarta, Mexico City and São Paulo[6]: *"Across the four cities, accessing data, maps, and climate projections was problematic. Information is scattered across many different agencies, departments, organisations, and research institutions, with some reluctant to share data. Enormous effort went into collecting the information that was made available. To benefit from and sustain this effort, setting up a permanent institutional home to maintain and update this inter-agency information in each city would be beneficial for any future work".*

The contrasting evidence between Baker (2011), Feldman (2011) and Koukoletsos (2012) presents an interesting conundrum, further illustrating the challenge of mapping in IDCs; through tests of quality, OSM was of a higher quality than the authoritative (MINUSTAH) and proprietary VGI (GMM) datasets, though it still had challenges regarding thematic attribute quality and in this situation data was available. Authority over data is effectively meaningless if a Geospatial Information providing authority does not have data in the first instance.

### 2.3.3 Geospatial Data Quality

Good quality geospatial data underpins notions of credibility and authority. ISO (2002) defines the quality as the *"totality of characteristics of a product that bear on its ability to satisfy stated and implied needs"*. Van Oort (2006) synthesising Longley et al. (1999) and Guptill and Morrison (1995) identifies five reasons for concern regarding the quality of geospatial data:

1. There is an increasing availability, exchange and use of spatial data;

[6]Some of the fastest growing and urbanising cities in the world

2. There is a growing group of users less aware of spatial data quality;
3. GIS enables the use of spatial data in all sorts of applications, regardless of the appropriateness with regard to data quality;
4. Current GIS offers hardly any tools for handling spatial quality;
5. There is an increasing distance between those who use the spatial data (end users) and those who are best informed about the quality of the spatial data (producers).

Research into spatial data quality can only occur once the fundamental process of deriving spatial data from the real world is understood. Aalders (2002) identifies two stages of spatial data collection;

1. Conceptualisation - the specification of what should be considered the real world and the abstraction of the selected objects;
2. Measurement - the specification of the measuring methods and the measurement requirements for capturing the data.

#### 2.3.3.1 Metrics of Quality

Quality has many definitions, this thesis considered the most recent ISO standard of Geospatial Quality, *ISO 19157:2013 Geographic information - Data quality* (ISO (2013)) and research into the data quality of VGI, these metrics are completeness, logical consistency, positional accuracy, thematic accuracy, temporal quality, usage and purpose, linege, semantic accuracy and metadata. Table B.1 presents the definition of these metrics, the country where the analysis was considered and the source.

| Quality Metric | Definition | Country | Source |
|---|---|---|---|
| Completeness | This is a measure of the lack of data; that is, an assessment of how many objects are expected to be found in the database but are missing as well as an assessment of excess data that should not be included. In other words, how comprehensive the coverage of real-world objects is. | England | Haklay (2010b) |
| | | | Koukoletsos et al. (2012) |
| | | Germany | Zielstra and Zipf (2010) |
| | | | Neis et al. (2012) |
| | | France | Girres and Touya (2010) |
| | | Haiti | Koukoletsos (2012) |
| | | USA, Spain, Cameroon | Barron et al. (2013) |
| Logical consistency | This is an aspect of the internal consistency of the dataset, in terms of topological correctness and the relationships that are encoded in the database. | France | Girres and Touya (2010) |
| | | USA, Spain, Cameroon | Barron et al. (2013) |
| | | Allenstone (fictional) | Goodchild and Li (2012) |
| Positional accuracy | This is probably the most obvious aspect of quality and evaluates how well the coordinate value of an object in the database relates to the reality on the ground. | England | Haklay (2010b) |
| | | | Haklay et al. (2010) |
| | | Germany | Zielstra and Zipf (2010) |
| | | | Neis et al. (2012) |
| | | France | Girres and Touya (2010) |
| | | Haiti | Koukoletsos (2012) |
| Thematic accuracy | As objects in a geographical database are represented not only by their geometrical shape but also by additional attributes, this measure evaluates how correct these values are. | France | Girres and Touya (2010) |
| | | Haiti | Koukoletsos et al. (2012) |
| | | Germany | Fan et al. (2014) |
| Temporal quality | This is a measure of the validity of changes in the database in relation to real-world changes and also the rate of updates. | France | Girres and Touya (2010) |
| Usage purpose and constraints | This is a fitness-for-purpose declaration that should help potential users in deciding how the data should be used. | France | Girres and Touya (2010) |
| Lineage/History | This aspect of quality is about the history of the dataset, how it was collected and evolved. | Germany | Mooney et al. (2011) |
| | | England | Mooney and Corcoran (2012) |
| | | France | Girres and Touya (2010) |

| Quality Metric | Definition | Country | Source |
|---|---|---|---|
| Semantic accuracy | This measure links the way in which the object is captured and represented in the database to its meaning and the way in which it should be interpreted | France | Girres and Touya (2010) |
| Metadata | This is detailed knowledge about the content of geographic data. Effectively, data that describes data | France<br>Haiti | Brando and Bucher (2010)<br>Poore and Wolf (2013) |

Table 2.1: Metrics of Geospatial Quality and Experiments on VGI Datasets.

Table B.1 demonstrates the geographic extent into research of geospatial quality, focusing on IACs. Instances of IDCs are few, bar cases presented by Koukoletsos (2012) and Barron et al. (2013).

The approach taken to assess metrics such as *completeness* and *positional accuracy* are comparative. Haklay (2010b) pioneered this approach, through comparing the street networks of OSM and Ordnance Survey: VGI verses authoritative data. The conclusions of this research broadly focus on comparing VGI with a reference dataset, indicating the relative completeness or accuracy. The comparative approach was taken by Haklay et al. (2010); Koukoletsos et al. (2012); Zielstra and Zipf (2010); Girres and Touya (2010); Neis et al. (2012); Koukoletsos (2012) and Fan et al. (2014). This depth of research into VGI quality contrasts with an approach where data is assessed on its intrinsic quality by Mooney et al. (2010); Mooney and Corcoran (2012); and Barron et al. (2013).

In situations where there is not a comparative dataset, assessing quality intrinsically is the only possible way forward.This represents a challenge to assessing the quality of VGI in IDC contexts. This is exemplified by Barron et al. (2013) while assessing the extent of data for Yaoundé the capital of Cameroon, noting that the majority of data has been imported and there is no active mapping community. As such, in the analysis there is little change in the geospatial features in the map, compared to instances in San Francisco, USA where features where subsequently updated.

This contrasts with the Haitian Earthquake, where many features were created over a few hours, whereas the timescale of Barron et al. (2013) covers 2009 to 2013. This further illustrates the challenge of mapping and data in IDCs, but demonstrates potential of citizen participation to bridge part of this gap.

## 2.4 Participatory Mapping

Geography is inherently a field which lends itself to participation of different groups of people, towards reaching spatial understandings about the world, from physical to human domains. This section discusses the themes and concepts of Crowdsourcing, Public Participatory GIS (PPGIS) and Participation focusing on IDC contexts, summarising how research and developments in these areas has led to the emergence of the domain of Crisis Mapping and Community Mapping.

### 2.4.1 Crowdsourcing

Volunteered Geographic Information is arguably an emergent field within Geospatial Information Science; however it can be framed within the older field of Crowdsourcing. To start with, the definition used for crowd source is taken from Howe (2006) *"Crowdsourcing is the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call."*

The crowd (however they are defined, be it citizens or other participants) has been used for centuries from 'the crowd' warning of invading armies to bird counting. Within the current age, bird counting was conducted *en masse* by the crowd since 1900. The Christmas Bird Count enlisted interested citizens into counting bird populations to a fine granularity that wasn't feasible previously, leveraging numerous people to conduct the survey Root (1988). This continues to the modern day, with examples including the aforementioned Audobon bird count Flanagin and Metzger (2008) to the crowdsourcing of imagery for the analysis of Flamingo populations (Iliffe et al. (2011)).

Crowdsourcing has a much broader scope than the data collection of counting various birds and wildlife. Wikipedia uses the crowd to gather data and information for their articles, Amazon's "Mechanical Turk" crowdsources various small tasks (Buhrmester et al. (2011)), OSM crowdsources geospatial data, and Ushahidi crowdsources problems within communities.

Projects such as OSM and Wikipedia are demonstrably successful crowdsourcing operations, but there are challenges and limitations such as the motivation of the crowd. Budhathoki and Haythornthwaite (2012) investigate the motivational factors behind OSM's contributors, finding a distinction between casual mappers who regard the principle of access to data as being important, contrasting with expert mappers who focus on the community of mapping. Similar conclusions were also found by Parker (2012), while considering the motivations of OSM from a Human Factors, as opposed to purely geographic perspective.

Platforms such as Ushahidi provide differing levels of motivation, where the output is still geographical, but also a report that serves to indicate an event. Similarly in IACs, tools such as "Fix My Street" allow the crowdsourcing of public service delivery issues. Crowdsourcing in this manner further indicates the nature of citizen participation, though literature on crowdsourcing activities by participants in IDCs is scant. Zook et al. (2010) and others discuss the Haitian Earthquake as a crowdsourcing activity by the crowd outside of Haiti, not the crowd *in and of* Haiti; understandable due to the prevailing circumstances. But local communities can participate in crowdsourcing activities as Hagen (2009, 2011) discusses regarding the crowdsourcing of data for Kibera and by Soden et al. (2014) in Nepal.

### 2.4.2 Citizen Participation in VGI and PPGIS

PPGIS is the concept of Public Participation in GISystems (GIS)[7]. PPGIS can be succinctly defined by Schroeder (1996) as being *"a variety of approaches to make GIS and other spatial decision-making tools available and accessible to all those with a stake in official decisions"*. While PPGIS is currently undergoing a renaissance in terms of research, there is a body of work dating back towards the 1970s, from supporting citizen participation in public planning (Nyerges et al. (2011); Carver et al. (2001)), protecting indigenous land rights (Jarvis and Spearman (1995)), to the mitigation of resource conflicts (Kyem (2006)). Sieber (2006) charts the historical origins of PPGIS, from its origins as a domain from "social narrative" (Kyem (2001)), to "a distinct community with the creation of new spaces". In providing a detailed literature review and discussion of the inception of PPGIS, Sieber notes that the interdisciplinary approach makes its precise definition complex, it being composed of a multitude of factors, such as *the public* but also other stakeholders and actors such as government agencies combing with technical factors such as enabling software and data producers. However, as Kyem and Saku (2009) discusses, this may not indicate true participation. This is amplified by Rambaldi et al. (2006) in discussing the various tools and their constraints and ensuring that there is good communication and governance between communities to enable the environment for PPGIS to succeed.

Tulloch (2008) considers whether VGI is participation, discussing that the *"the overlap between PPGIS and VGI relies on the investigation by individuals of locations that are important to them"*, though pointing out that at times, such use of technology in PPGIS leads to unintended consequences citing the case of Hodgson and Schroeder (2002). Here, outside researchers aided local Maasai groups in mapping the extent of their lands, but at a cost; boundaries of local resources were identified and access was then denied based on these maps. In IACs, this has ethical implications; in IDCs, especially for marginalised communities, the removal of access to basic public services, while still being ethically questionable could also lead to potentially severe life impacting circumstances.

These concerns are amplified due to what Elwood (2006) terms as the *"mainstreaming of PPGIS"*, further expanding on this in Elwood (2008) to show how VGI is changing how we engage with geography and maps. Neogeography and crowdsourcing are enabled by the ubiquitous nature of technology in IACs, though this is not replicated wholly in IDCs with advancements in other areas such as mobile financial services, lagging behind technology like smart phones.

For the purposes of examining community mapping in IDCs, this thesis takes PPGIS as the realisation that GIS can empower excluded communities and is in part an extension of Peluso's argument of counter mapping, while respecting the previous PPGIS challenges raised by Hodg-

[7] A closely related, but distinct concept to GIScience, where GIScience is the body of knowledge that GISystems implement and exploit - Longley et al. (2015)

son and Schroeder (2002). Section 2.5 discusses this case in-depth further in this chapter, by examining the emergence of community mapping.

### 2.4.3 Participatory Frameworks

As this thesis is concerned with the participation of citizens in community mapping, understanding the extent of citizen participation is necessary. Schlossberg and Shuford (2005) examines the concepts of the public and participation with relation to PPGIS, comparing differing frameworks and "ladders" of public participation, introducing and comparing the frameworks of Arnstein (1969), Connor (1988), Wiedemann and Femers (1993), Carver (2003), and Chambers (2006):

- The Arnstein (1969) framework has become the most well known text, framing participation in terms of citizen power. This framework works on a spectrum, from *"manipulation"* (the bottom rung) to *"full citizen control"* (the top rung);
- Connor (1988) delineates between *"Leaders"* and the *"General Public"* and focuses on conflict avoidance and resolution in a public policy decision-making process;
- Wiedemann and Femers (1993) developed their ladder from understanding how citizens participate in environmental management. This was aimed to consider public enfranchisement in public decision making, starting with *"public right to know"* (the bottom rung) to *"public participation in the final decision"*. In doing so, this focuses on how public participation occurs in governmental processes, investigating cases of waste management in Germany. These cases examine how the public interface with regional and city governments, advocating that *"public participation is a means, not a goal and may create additional problems in and of itself"*(p367). This is a limiting, ethnocentric perspective and not ethically compatible with conducting research in IDCs, but it is indicative of wider challenges in participation between the public and governments;
- Carver (2003) developed his ladder to look at citizen participation through the medium of the internet, discussing how constraints such as connectivity can inhibit participation in the 'civic commons of cyber space'. This is further identified as a challenge by Nyerges (2009), in discussing the unrealistic expectation that public participation will move wholly online for indigenous communities;
- Chambers (2006) looks at the relationship between totalitarian participation through to self-mobilising participation, towards typifying levels of public empowerment. Specifically considering the use of 'ground maps' and paper maps, whilst also considering the role of community outsiders within participation in the actions.

From the IDC perspective Guaraldo Choguill (1996) presents a ladder of participation for developing countries, building upon Arnstein (1969) ladder. This advocates the usage of the term *community participation* in lieu of *citizen participation*, as this *"considering individuals as*

*members and representatives of a fully organised community*. This presents a challenge for the selection of appropriate framework. In that the ladder of participation of Guaraldo Choguill focuses on the IDC context, whereas Arnstein's is a general framework, though is preferred as the framework to assess citizen participation in VGI (Sieber (2006); Seeger (2008); Tulloch (2008); Ganapati (2011)). On the basis of its generalisability and existing grounding in VGI, Arnstein (1969) framework is preferred by this thesis, though this does not discount the merits of GuaraldoChoguill's approach, specifically her comments on community.

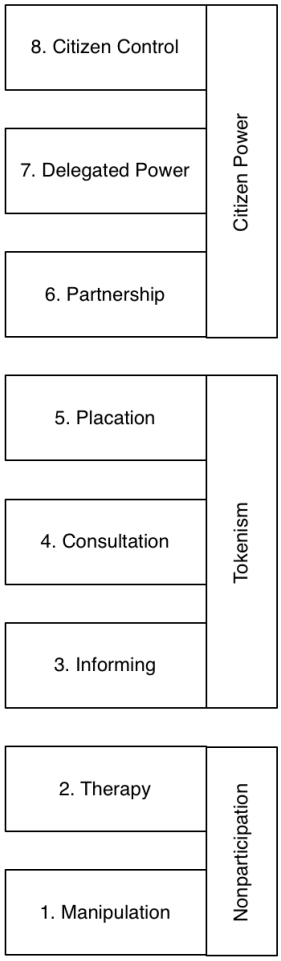


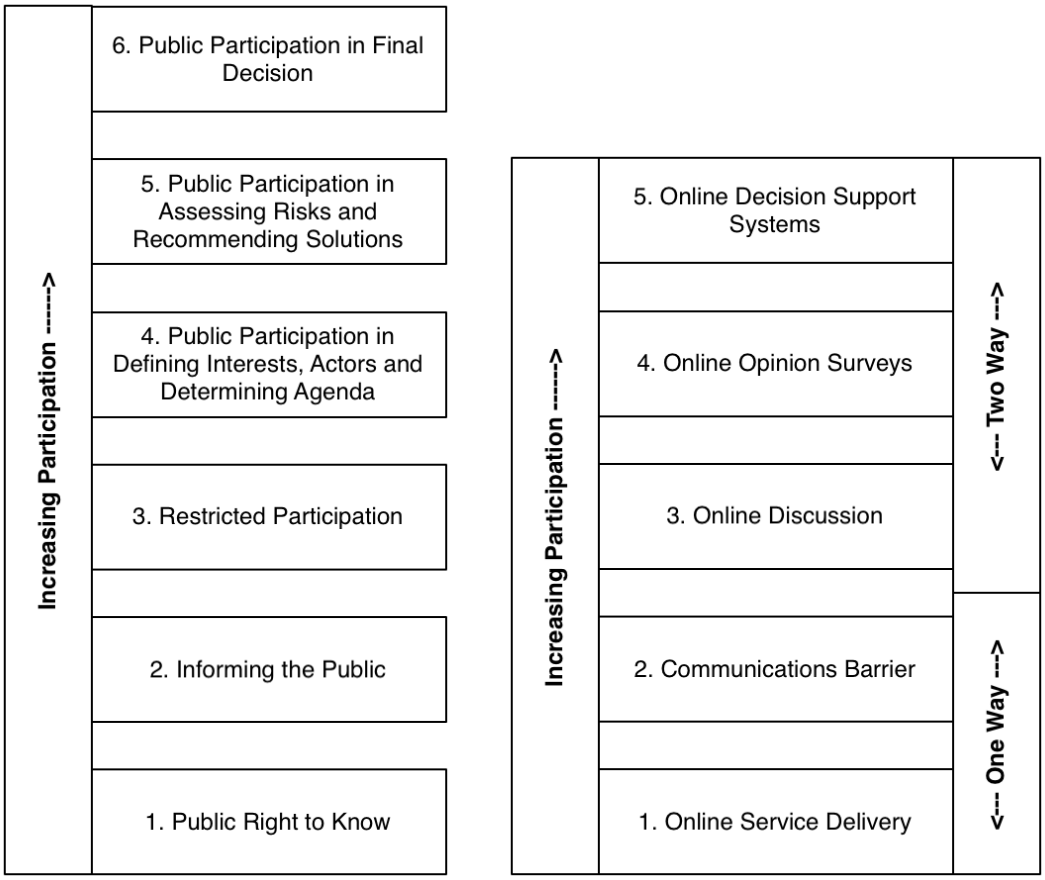

Figure 2.3: Arnstein's Ladder Of Citizen Participation

Arnstein (1969) outlines a conceptual framework for citizen participation within projects, as visualised in Figure 2.3[8]. The bottom rungs of the ladder are (1) Manipulation and (2) Therapy. These describe levels of 'non-participation' and coercion. As discussed the real objective is not to enable people to participate in the process, but to enforce an ideology onto the participants. Rungs (3) Informing, (4) Consultation, and (5), Placation progressively indicate levels of token participation, but ultimately fail to enfranchise participations or allow them to change the direction of the project. Towards the upper rungs of the ladder are levels various degrees of

[8]This is adapted from adapted from Arnstein (1969)

citizen power and according levels of decision-making impact. (6) Partnership is indicative of a capacity to negotiate and compromise with traditional power holders. At the topmost rungs, (7) Delegated Power and (8) Citizen Control citizens have capacity to fully make decisions as they see fit and liaise with traditional power structures.

Through considering participation in this abstracted manner, it is possible to assess the participation of the citizen or community within projects. Ideally, this is done so that communities and their citizens are taking *citizen power*, as opposed to *tokenism* or *non-participation*. Specifically, given the context, the *manipulation* of citizens in IDCs[9] is unethical.




(a) Wiedemann and Femers's Ladder (b) Carver's Ladder

Figure 2.4: Successor Participation Ladders

Figure 2.4[10] compares the ladders of Wiedemann and Femers (1993) (Figure 2.4a) and Carver (2003)[11] (Figure 2.4b) respectively. Both of these ladders are relevant to this work, however,

[9] Pragmatically any citizen in the world, though the consequences are potentially worse in IDCs

[10] Adapted from Wiedemann and Femers (1993) and Carver (2003) respectively

[11] This is presented in Carver (2003), referencing an unpublished master's thesis. Accordingly, Carver is referenced for this work, though it belongs to E. Smyth's 2001 MRes Thesis, *Would the internet widen public participation?*.

are not as relevant as Arnstein's more adaptable framework. Within the case of Wiedemann and Fermer, the ladder's 3rd rung indicates 'restricted participation', as community mapping is primarily a community based activity, to typify its participatory nature the base rung of the ladder needs to start with community participation. Similarly, Carver's ladder considers public participation in on-line spaces. Community mapping can involve data being uploaded online, however, it would be completely unrealistic to expect informal, unplanned environments in IDCs to move to a wholly on-line process for community participation, especially when existing societal structures in community forums exist.

Chamber's ladder specifically considers the context of producing 'ground maps'[12] and 'paper maps' in IDC environments. However, the ladder is framed between Totalitarian (i.e. coercion) and Self Mobilisation participatory modes. The charged nature of the ladder automatically assumes malicious intent of non-public actors, this should be contrasted by rephrasing Hanlon's razor - *do not ascribe to malice, what can be given to lack of capacity*. While Chamber's ladder may be appropriate in the context of the challenges faced by indigenous communities in gaining land rights in the context of community mapping, all actors are working together towards a common goad. This complexity against Arnstein's ladder is an avenue of future research, but one which is unfortunately out of scope for this thesis.

Consequently the ladder of Arnstein (1969) is appropriate for typifying participation, as this framework is adaptable to the IDC context, without the limitations of other frameworks. Furthermore, this framework considers the role of the individual citizen, as opposed from a governmental angle from the VGI perspective, this is reinforced by Tulloch (2008).

In assessing communities and participation in VGI, it is prudent to delineate between the differing communities and their location. As previously discussed in Section 2.3 and shown in Figure 2.2 communities creating maps and VGI of their locations can map remotely. The origins of this lie within the realm of Crisis Mapping.

### 2.4.4 Crisis Mapping

Okolloh (2009) charts the initial beginnings of Crisis Mapping through examining the case of the Kenyan election violence of 2007 - 2008. Meier (2011). In response to this, Ushahidi (Swahili for "*Witness*") was created that allowed Kenyans to submit anonymous reports about what was going on around them, from violence to other issues.

Subsequently, the Ushahidi platform was used to crowdsource events in crises, such as the Haitian (Norheim-Hagtun and Meier (2010); Zook et al. (2010); Roche et al. (2011)), Chilean earthquakes (Liu et al. (2010)), and the Japanese Tsunami (Meier (2012)) that is indicative of a

[12]Maps drawn into the ground.

wider movement of the crowd volunteering time, enabled through participatory technology, such as OSM, or through platforms such as Missing Maps to elicit data, such as geospatial data for maps.

Ziemke (2012) discusses the emergence of crisis mapping and its interdisciplinary nature[13]. Due to the numerous disciplines, difficulties exist in finding a common language and methodological approaches, but as Ziemke discusses *"access to effective and detailed street maps like OpenStreetMap are essential for effective crisis mapping"*.

## 2.5 Community Mapping

In contrast to Crisis Mapping which primarily occurs as a remote activity by the crowd, Community Mapping occurs within and by communities. Community produced maps historically predate NMAs, when questions on their authoritativeness and quality were not questioned; examples of this include the navigational charts of the Micronesian Marshall Islands discussed by Akerblom (1968), which were used for millennia, well before their exploration by European explorers and traditional cartography. But the techniques and methods of production have been lost.

Within recent literature on PPGIS and VGI, investigating community mapping is in a renaissance. Parker (2006) defines community mapping as *"a map, produced collaboratively by residents of a particular locale, often featuring local knowledge and resources"*. This is subsequently expanded by Perkins (2007): synthesising from Aberley (1993) and King and Clifford (1985) in producing an agenda for Community Mapping;

- *"reasserting indigenous people's rights;*
- *re-publishing the past for contemporary consumption advancing local claims to land;*
- *re-mapping lost place-names;*
- *protecting local wildlife in the face of development;*
- *conserving landscapes threatened by agribusiness;*
- *protesting against planners;*
- *opposing military power;*
- *rejecting surveillance;*
- *showing the powers-that-be what might be locally distinctive."*

Elwood (2006) describes how GIS and community participation can work in developing plans in a neighbourhood of Minneapolis, Minnesota, USA; Perkins (2007) examines the mapping

[13] As it is *"situated at the nexus of many fields, drawing from debates in disciplines as diverse as: geography, epidemiology, sociology, environmental science, political science, forestry, ecology, psychology, linguistics, robotics, communication, cultural studies, statistics, mathematics, conflict studies, art and design, computer science and disaster and emergency management"*.

of parishes in rural England; Perkins (2008) looks at the community mapping of golf courses; Amsden (2005) looks at how the youth in Vancouver can be engaged to create maps.

These instances indicate that a majority of literature focuses on IAC instances of community mapping, though some research exists in IDCs. Perkins (2007) framework is current with regard to community mapping in IACs, it is bereft of the factors which are important in community mapping in IDCs and offers no comment on whether a delineation of factors exists. While these factors may indeed become important, a different agenda exists for the production of community maps. This view is reinforced by Parker (2006) looking at how Community Mapping is *"a response to conventional, elitist cartography, comprising an alternative, egalitarian counter- culture"*. She provides a case study of the Portland Greenmap and its contributions to themes of inclusion, empowerment and transparency in allowing the 'community' to creating their own parks and green spaces. This is paralleled by Carver et al. (2001) looking at the model of participation in a participatory planning exercise in Slaithwaite, United Kingdom. These cases are focused on the IAC context, not an IDC, however.

### 2.5.1 Community Mapping in IDCs

Within IDCs, Peluso (1995) in Indonesia introduces the term counter mapping specifically with respect to the mapping of forestry. Counter mapping is described as a 'political act', used to counter official maps which allegedly demarcate resources in a manner not befitting the local community's claims to forest resources. She further discusses that counter mapping is *"a uniquely late-twentieth century phenomenon, made possible by both technological developments and the last decade's push toward participatory politics and management strategies"*.

Jarvis and Spearman (1995) discuss community mapping in Bolivia (albeit under the more general term of "Geomatics") describing a similar case to Indonesia, where indigenous groups living in forests were under threat due to instability in land rights and encroachment by outsiders. The case is interesting due to its assessment of how the mapping was organised, but also brought the community together: [the] *"challenge in working with the Yuquì was not only to operationalise the demarcation and mapping of their territory, but to help rebuild their fading sense of identity and the internal strength it provides."*. This indicates that communities can be strengthened through the process of mapping and that the output is not just a map.

In Tanzania, Hodgson and Schroeder (2002) discuss how *"mapping against dominant power structures"* has occurred locally in Tanzania, discussing how counter mapping has demarcated land rights between local tribes of Maasai and supported the study of wildlife ecology in Tarangire National Park. Combing international experts with members of the local Simanjiro community. This with the aim of developing data collection strategies to understand wildlife migration patterns between Tarangire and Simanjaro plains. These would subsequently be

used to for wildlife preservation corridors, to protect the animals.

No further explanation on how this data was collected is provided or on the techniques employed and used. Additionally, this had unintended consequences as discussed earlier in section 2.4.2 where land was mapped by local Maasai, then resources were subsequently denied to them. This further illustrates the challenging nature of IDCs.

Within the counter mapping literature, the mapping is almost presented as a *fait accompli* focusing on how the mapping is beneficial for the community in which the mapping occurs, at the cost of neglecting the mapping method. Counter mapping, as a term, is also a very political; inferring that the mapping is against some thing, usually power or authority. This is a limiting view: while challenges exist in collecting GI in IDCs, the view of this thesis is that lack of spatial data is driven through lack of policy and governance.

This is at the crux of the argument of Hagen (2011) on mapping Kibera, an informal settlement in Nairobi, through the Map Kibera community mapping project. Hagen acknowledges that formal power structures have a participatory role, but that the 'crowd' can have a role in determining how map data is collected while also describing the process of mapping.

Further upon this theme of uploading community mapping data into OSM, Pánek (2013) investigates community mapping in a Koffiekraal, a South African township, and claims to investigate the process of community mapping. Though ultimately discusses the differences of VGI technology between OSM and Google Map's Map Maker project. There is no further examination of how such map was created bar digitisation into OSM, with no explanation of the social community which created the map nor of the technical process, which is what this thesis investigates.

## 2.6 VGI and Socio-Technical Systems

As indicated by Ziemke (2012) in section 2.4.4, the map is one component of a much larger system and provides the start for tools to be built, using VGI as the initial starting point. This presents a 'chicken and egg' problem: potentially new tools could be developed that enable the capturing of VGI, but require VGI to inform how such tools are built. This challenge is amplified in IDCs, where resources and funds are relatively scarce; combined with the lack ability to develop such tools, this means that the majority of tools developed for IDCs are created and designed by those in IACs, allowing for non-traditional approaches to the development of tools to be applied. This is part of a much larger issue of how socio-technical systems, specifically those within the geospatial realm can be designed and understood.

Rasmussen (1988) considered this challenge with regard to risk management and the design of systems that incorporate geographic information. While this is not as extensive an analysis

as presented later in Chapter 6, this lays the foundation for understanding geographic information as a work domain. Furthermore, GIS is suitable for modelling as a socio-technical system due to the interfaces and complex user tasks that are undertaken (Kuhn et al. (1992) and Haklay and Tobón (2003)). Petch and Reeve (1999) further establish this within the terms of socio-technical systems, though use more traditional ICT focused models (the waterfall model) to describe how a GIS system should operate. This prescriptive approach is contrary to the participatory approach of community organisation, as it provides norms to be followed, this raises the question of how to design socio-technical systems appropriately, with the IDC context.

In discussing the role of society and GIS, Nyerges (2009) discuss how the role of GIS needs to be relevant to all, especially with regard to indigenous populations. Here the design of the socio-technical system is of paramount importance, if the system is too complex, then it will not be understood nor used. In part response to this, Nyerges et al. (2012) frame GIS within the domain of Human Computer Interaction (HCI). In doing so, this offers an opportunity to study the new domain of community mapping as a socio-technical system, while supporting the validity of applying socio-technical methods to the geographic domain. This allows methods such as Cognitive Work Analysis (CWA) to be applied to community mapping. CWA is a method that allows for the understanding of complex socio-technical systems through understanding the form and design of the work domain, allowing for the constraints of the system to be identified. This supports the development of more respectful systems, as they do not treat workers within them as cogs in a machine by prescribing actions. By contrast, a CWA charts the work domain as a formative system, allowing workers to chose the optimum method for their work (this is discussed in detail in the following chapter).

### 2.6.1 (International) Development by Design

Community mapping as a work domain is barely researched in IACs, completely negating the IDC context. There is a vast body of research within the design space of ICT projects in IDCs generally however. Vasdev (2013) discusses design thinking specifically with regard to the development of tools in the realm of ICT4D (Information Communication Technology *for* Development) situating this challenge directly within User Centred Design (UCD). This view is reinforced by Heeks (2002) in discussing challenges and failures of information systems in IDCs. Specifically noting the *design-actuality gap* between the requirements of a tool for the actuality of the ground and the design of the tool.

Haklay (2013b), in approaching the same challenge from a VGI perspective, specifically discusses the case of Map Kibera, where development of new tools was conducted with the local community, as opposed to be designed and deployed without respect to the local actualities. This ensures a local community, while potentially not having the skills to develop themselves,

can situate the technology and test iterations. If this is not the case, then the project stands a high probability of failure. Fast and Rinner (2014) exemplifies this notion discussing the "Dead Ushahidi" project[14], which is a collection of "purposeless" Ushahidis. Meier (2011) discusses factors, such as training that could be due to the non-adoption of tools, but challenges to adoption and use can also be seen through the perspective of Heeks (2002) or Arnstein (1969), specifically regarding the higher rungs of *Citizen Power* in the ladder of citizen participation.

This approach contrasts with earlier ICT4D research, where Heeks (2003) takes a techno-pessimistic approach towards the development of technology for development, providing three factors for the use of ICT for improving governance in IDCs:

- ***Total failure**: the initiative was never implemented or was implemented but immediately abandoned;*
- ***Partial failure**: major goals for the initiative were not attained and/or there were significant undesirable outcomes;*
- ***Success**: most stakeholder groups attained their major goals and did not experience significant undesirable outcomes.*

At the time, this was a valid finding, according to this taxonomy when investigating ICT projects in developing countries, *"35% were total failures, 50% were partial failures and 15% were successes"* with financial and political reasons cited for failure.

### 2.6.2 Towards a Systems Approach

Wilson (2014) discusses the emergence of research into systems, grounding it in the domain of ergonomics and human factors, ultimately synthesising his own definition:

> *"A system is a set of inter-related or coupled activities or entities (hardware, software, buildings, spaces, communities and people), with a joint purpose, links between the entities which may be of state, form, function and causation, and which changes and modifies its state and the interactions within it given circumstances and events, and which is conceptualised as existing within a boundary; it has inputs and outputs which may connect in many-to-many mappings; and with a bow to the Gestalt, the whole is usually greater (more useful, powerful, functional etc) than the sum of the parts".*

Choosing an appropriate method for exploring and defining community mapping in alignment with the research questions, aims, and objectives of this thesis, points to community mapping being a system. It is the intersection of differing social communities, technology and

[14] http://irevolution.net/2012/07/05/deadushahidi/

the physical world coming together, leading to a map being created. This aspect of the social and technical is also important, through socio-technical systems theory.

In framing community mapping as a socio-technical system, methods from Ergonomics and Human Factors become available to examine it. An alternative approach would be to take a purely Grounded Theory approach. This approach would be limiting in terms of this thesis' objectives, to not only *describe* community mapping in IDCs, but to understand the *design space* of community mapping and hence it is necessary to investigate VGI in IDCs using a socio-technical systems approach.

Savelyev et al. (2011) coined the term "Volunteered Geographic Systems", proposing that volunteers could submit or request services in their community. Thatcher (2013) discusses how VGI has focused around projects such as OSM and Ushahidi, presenting a distinction between the (Volunteered) Geographic Information and the VGS' responsible for decision making and action coordination, describing two hypothetical case studies of VGS around crisis situations of snow storms and flooding. Though, like PPGIS, there is ambiguity around the study of systems using VGI data. Schade et al. (2010) discusses the same concept of using VGI in crisis (also flooding) drawing on literature on Human Sensor Webs (HSW). Likewise, Goodchild (2009) frames VGI and Neogeography within the field of Location Based Systems (LBS).

This ambiguity in definition of terms is indicative of the emergent nature of the field of VGI and the current extent of knowledge around systems using VGI. This places VGI within the realm of Ergonomics, specifically within the theory of socio-technical systems. Klein (2014) discusses the nature of socio-technical systems, arguing that the technology and people in socio-technical system are interdependent, each affecting the other. When applied to VGI, this theory encompasses both the social and technical, namely the volunteers creating or using the information or system and the technical systems themselves.

In taking a socio-technical systems approach, the impact of the ambiguity of defining the characteristics of VGI is minimised, due to the background and established nature of the theory. This history is discussed by Eason (2014) noting the field's evolution from understand how tasks are conducted by workers to supporting the design of new systems.

## 2.7 Discussion

In considering the literature of Geospatial Information Science (GIScience) Volunteered Geographic Information (VGI) and community mapping in Industrially Developing Countries (IDCs) it is apparent that gaps exist across these disciplines regarding the praxis of community mapping as evidenced in section 2.5.1, presenting the need for this thesis.

Arguably, there is no apparent reason why the methodologies for analysing spatial data within IACs should differ when analysing data from IDCs, as Koukoletsos (2012) demonstrates with respect to data from Haiti. However, Haiti was a unique context. This approach is challenging as comparative methods of analysis can only be applied if reference datasets are available. As discussed, this is often not the case in IDCs, necessitating a different approach to the assessment of data quality.

Haklay et al. (2010) when testing Linus' Law, *"Given enough eyeballs, all bugs are shallow"*, in four areas of London, comments on the large variation of completeness between an authoritative dataset and VGI dataset: *"This range of values is not surprising, because the information is provided by many participants, who are acting independently and with loose coordination"*. The model within community mapping involves collocated, synchronous work, ultimately producing VGI contrasts with this statement, but no investigation into the quality of community mapping data has yet been conducted, as noted in Table B.1. Potentially, community mapping provides the *"eyeballs"* for quality and is discussed in Chapter 4.

Due to the academic discourse of VGI and its quality primarily focusing on comparative studies into the authoritative nature of VGI, subsequent investigations into its quality have focused on IAC contexts. This unintentional ethnocentricity presents an opportunity to explore the characteristics of VGI in IDCs, towards investigating how it collected, by whom, its quality, and how it is used. This requires an understanding of the theoretical underpinning of citizen participation generally with a focus on GIScience.

Crowdsourced VGI maps are a unifying factor, enabling research into emergent fields of crowdsourcing, PPGIS and crisis mapping, the key element being the participation of a community. This starts to indicate a necessary shift in how traditional values of Geospatial Information discussed in section 2.3.2.2 could change as emergent concepts of VGI and crisis mapping become established.

This shift is already occurring, with Lohr (2011) discussing the impact of Google, Microsoft and others in having an impact in how the United Nations and other inter-governmental institutions are helping democratise mapping. Haklay (2013b) discusses this democratisation comment, rightfully urging caution. Ultimately VGI is just information and without the systems and tools that enable its use and engagement, it cannot be used appropriately, regardless of data coverage or perceived quality, thus necessitating an understanding of how tools can be designed that understand the context of community mapping, building upon its data. The comparison of Koukoletsos (2012) and Soden and Palen (2014) demonstrate a challenge for VGI in developing countries, even though tools are available to create data in environments that are comparatively data poor and data can be created rapidly and used on the ground. The challenge is that this data may not have completeness of attributes as it is largely created by remote volunteers. This has been seen since the emergence of crowd-sourcing, such as the

digitisation of aerial imagery for disaster response, since the Haitian Earthquake of 2010 and during the Typhoon Haiyan (Westrope et al. (2014)).

The large scale, remotely collaborative efforts of crisis contrast with community mapping where contributors aren't spatially distributed working asynchronously but are directed, co-located, working in teams. This approach, from the community level contrasts with Haklay et al. (2010);*"data collection by amateurs, the distributed nature of the data collection and the loose coordination among them"[sic]*, contributing to OSM.

OSM has been at the centre of the rise of VGI. Ramm et al. (2011) compares the project to the rise of Wikipedia, the free encyclopaedia that anyone can contribute to and edit. Like Wikipedia, OSM was not breaking new ground in Industrially Advanced Countries, as for those who required or desired access to information, whether encyclopaedic or geographical, other options existed such as the Encyclopaedia Britannica or data from NMAs respectively. This thesis advocates that the real value of VGI is not in countries that have access to geospatial data. Community mapping offers an opportunity to collect detailed VGI in environments which sorely need Geospatial Data for basic provision of services and other essential governance challenges. The majority of the scholarly discourse has focused on IAC contexts, this thesis therefore will attempt to bridge this gap, towards understanding the role, characteristics of VGI and tools that create and use VGI in IDCs.

## 2.8 Chapter Summary

This chapter described the emergence of the theories of VGI, Community Mapping and VGS charting their history and relevance to each other and this thesis. Specifically, this focused on the emergence of community mapping, considering how concepts such as counter mapping and VGI have enabled emergent projects such as Map Kibera. Alongside this theoretical analysis, tools that enable community mapping and VGI were discussed, identifying a need for an approach to consider the development of new tools using volunteered, crowdsourced data. The following chapter examines and defines the problem statement of this thesis.

# Chapter 3

# Research Methods

## 3.1 Introduction

This chapter introduces the methods used to answer the research question identified within the introduction. The methods explained in this chapter come from a diverse range of theories and fields, necessitated by the interdisciplinary nature of this thesis. As such, the aim of this chapter is to ground the subsequent chapters' empirical work in established theory and practice and to discuss the various applicable methods that can be used to answer the research question. This is then amalgamated into a *Thesis Audit*, by recalling the thesis diagram of Chapter 1 and making the addition of where the chosen methodological approaches integrate to resolve the research question, aims and objectives in the proceeding chapters.

## 3.2 Socio-Technical Systems

Section 2.6 introduced the concepts of socio-technical systems. Furthering this, Salmon et al. (2010) discuss the two main methods used to understand socio-technical systems, Hierarchical Task Analysis (HTA) and CWA. As discussed in the previous section, CWA was chosen as the applicable tool to examine community mapping as a socio-technical system. This is due to the high-level view afforded by CWA of how the system could function, as opposed to HTA which shows how the system should function. Salmon et al. (2010) on comparing the difference in methods notes this difference in granularity, noting that HTA *"details button pressing activities"* in contrast to CWA, which *"can specify, at a high level, what functions are required, how they are undertaken, in terms of high level strategies and by whom"*.

This aligns with Rasmussen's three main models for understanding systems: *Normative*, *Descriptive*, and *Formative* (Rasmussen et al. (1994a)). Normative models describe how a system

should work, and is contrasted by Descriptive models which describe how a system actually works. Formative models which describe requirements on how the system could work. Jenkins et al. (2006) takes these definitions, comparing the methods of HTA and CWA, and state *"CWA is a formative approach, whereas HTA seeks to fit somewhere between descriptive and normative [models]"*. *Vicente1999* further adds critique of a normative approach, in stating that *"workers do not, cannot, and should not consistently follow the detailed prescriptions of normative approaches"*

In selecting between which method of CWA or HTA, the selection is not on the method, but on the approach. Here a formative approach is necessary, based on two factors. Firstly, the ethical dimension is important, it is not ethical for a western researcher to prescribe approaches, it goes against the ethos of community mapping. Secondly, the research problem of this thesis necessitates an approach to understand community mapping as a socio-technical system, not to prescribe the form of this system. As such, the formative approach and CWA will be used as the method to examine community mapping.

As multiple strategies exist for conducting real world research into socio-technical systems exist, it is important to understand how they are related to understanding how systems work. As elaborated upon previously in Chapter Two, socio-technical systems are the harmonisation of social and technical phenomena, namely community members and the technical process of mapping. Accordingly, the following subsections explain the vocabulary, definitions and method of CWA and how it relates to the resolution of this thesis' RQ.

### 3.2.1 Cognitive Work Analysis

Generally, in socio-technical systems the design and development precede the system's evaluation. This approach works when dealing with a tabula rasa, though is less appropriate when typifying an emergent system, as is the case with community mapping. Research Objectives 2 and 3 of this thesis are to "examine the praxis and characteristics of community mapping in IDCs" and "determine the constraints of the design space of community mapping in IDCs". Accordingly, CWA can provide a series of tools to evaluate first the system(s) already in place, and then develop recommendations, following a descriptive then formative approach for future design. However, prior to designing tools, it is necessary to understand the environment in which the tools are used, this environment is termed the *"design space"* in terms of CWA.

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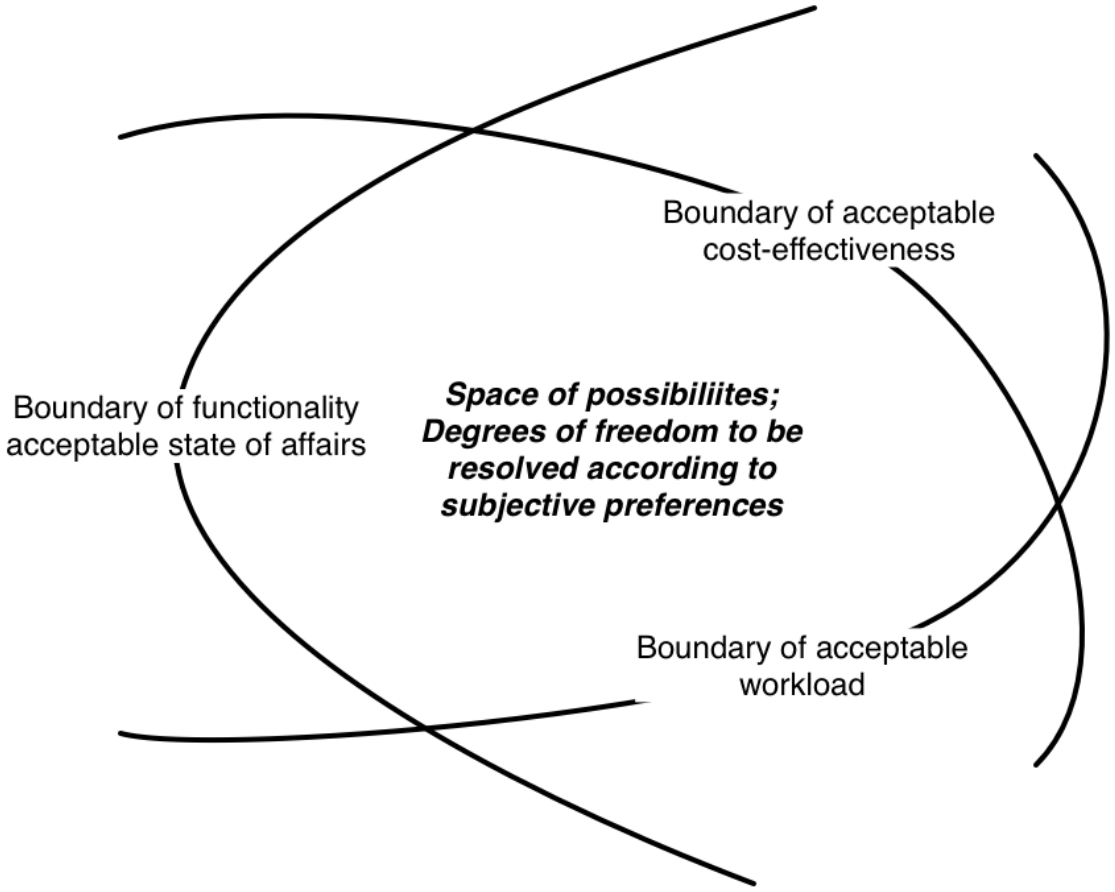


Figure 3.1: The Design Space

By understanding the goals and constraints, a formative design space is created. Fidel and Pejtersen (2004) notes that there are four factors that actors within CWA that can be used to construct the design space:

- The work actors do;
- Their information behaviour;
- The context in which they work;
- The reasons for their actions.

In each of these factors, there is not one dominant factor, each are as important in understanding the work and tasks of community mapping.

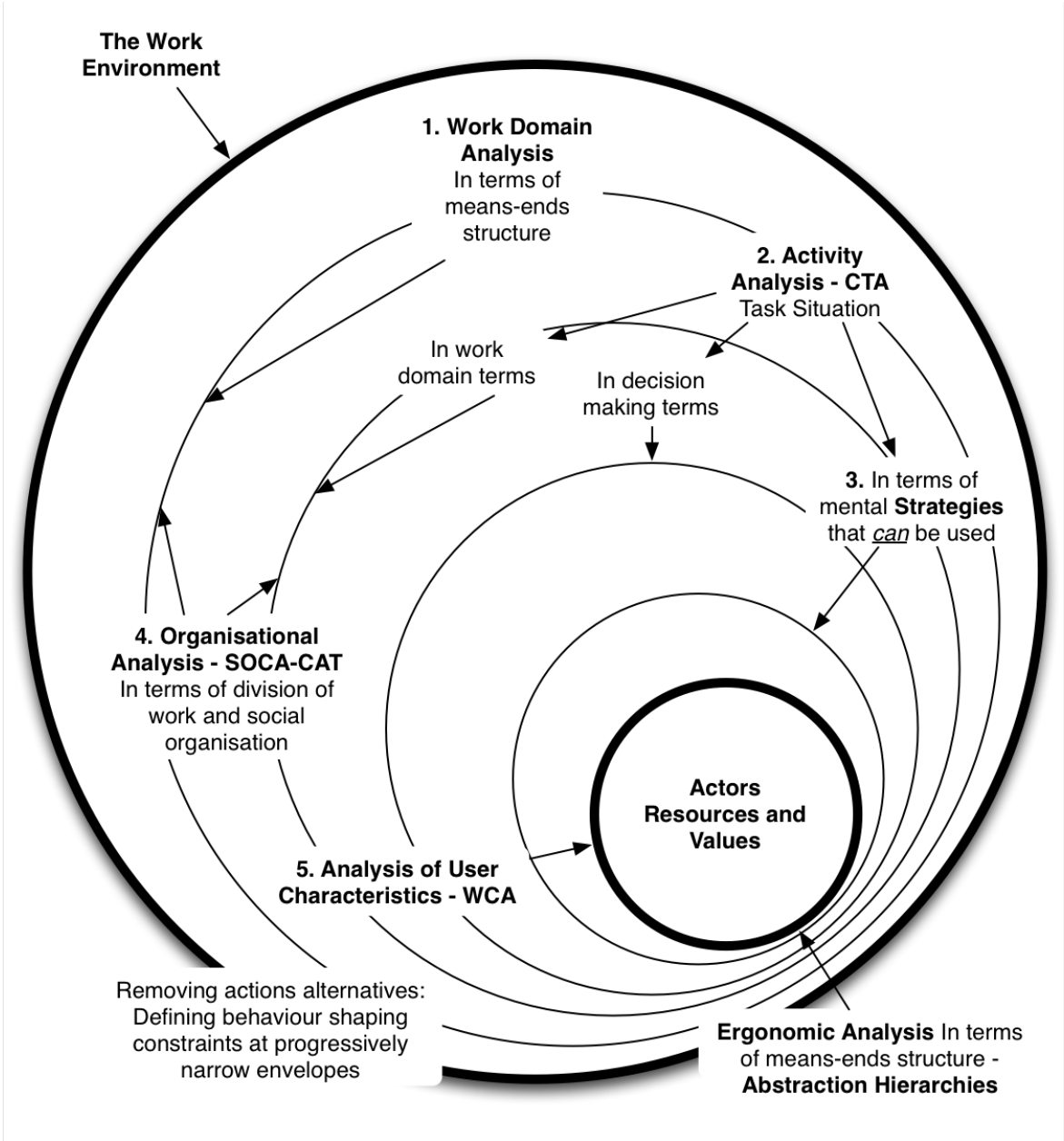


Figure 3.2: Methods of Cognitive Work Analysis

Figure 3.2[1] diagrammatically represents these factors and how they interact, providing a visual representation of the work space, in future chapters, this will be utilised to describe community mapping and to decompose community mapping's various processes, creating a conceptual framework. These factors in executing a CWA distil into five phases:

1. Work Domain Analysis
2. Control Task Analysis
3. Strategies Analysis
4. Social Organisational and Cooperation Analysis

[1]Interpretation from Fidel and Pejtersen (2004)

5. Worker Competencies Analysis

The resulting analyses provide a through understanding of the socio-technical system being studied, for this thesis, community mapping. The subsequent sub-sections further examine the methods of CWA.

### 3.2.2 Phase 1: Work Domain Analysis

The work domain describes *"the environment in which workers operate, identifying a fundamental set of constraints that shape activity within the system"* (McIlroy and Stanton (2011)). This is achieved by building an Abstraction Hierarchy (AH), this process was first described by Rasmussen (1985) as a tool to represent knowledge within a decision making process. The AH describes the various abstracted levels of the system, at its highest level, it describes the system's functional purpose and at the lowest, the physical objects of the system. For example, within community mapping one functional purpose would be the need to provide geographic information, the physical object to provide it would be a GPS. This understanding of the interrelationships between the levels in an AH is referred to as the *means-ends* network.

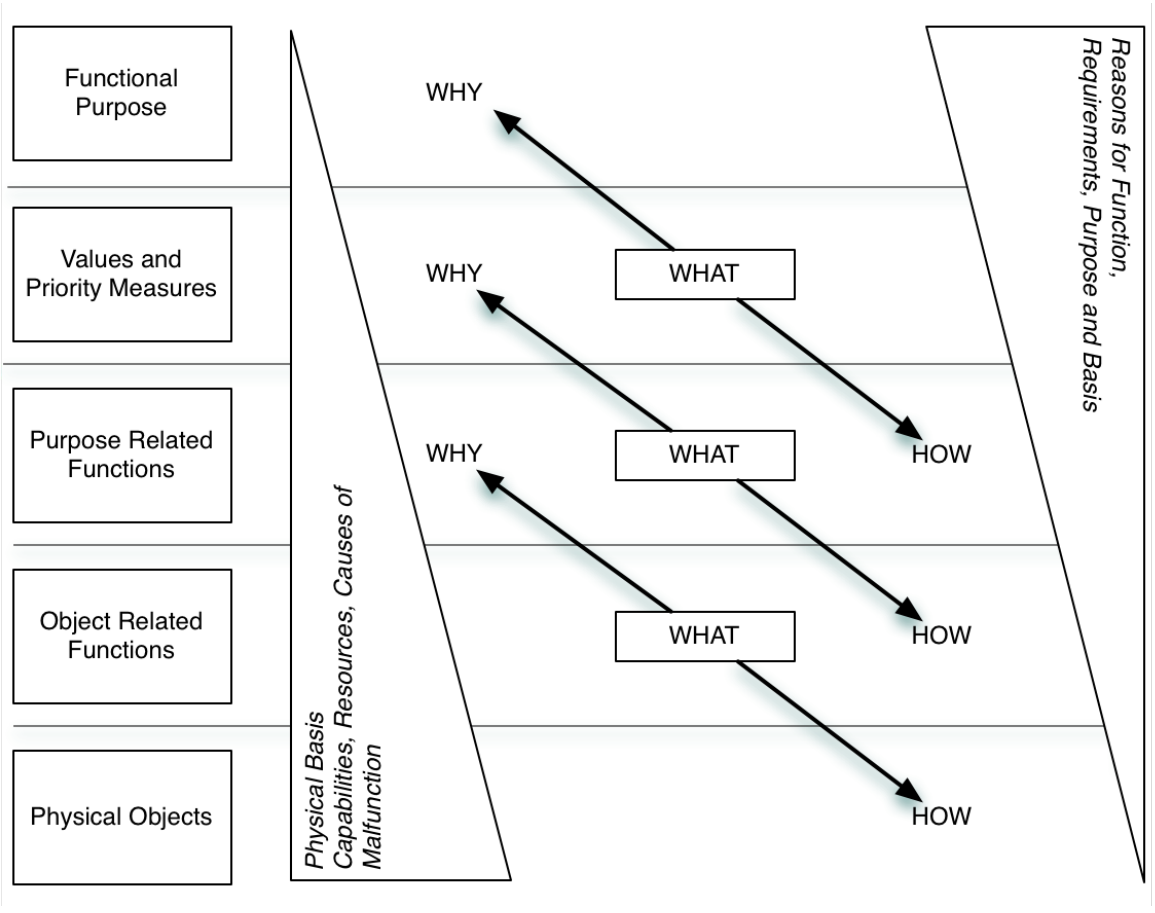


Figure 3.3: The Abstraction Hierarchy

Figure 3.3 synthesises the diagrams of Rasmussen (1985) and Rasmussen et al. (1994a) in both representing the AH and the means-ends network demonstrating how these concepts relate to each other. In transitioning between the differing levels of the AH, those related objects at a higher level provide reasoning on *"why"* a task is conducted with those at a lower level being resources that enable the functionality of a task, the *how* such task is achieved. For example, within for the 'Object Related Process' of Cartography, a *"Purpose Related Function"* would be to understand Land Use, this would be enabled by the *"Physical Object"*, GPS. Importantly, these are not direct, one-to-one relationships; they are inter-relational and interconnected in a many-to-many relationship.

### 3.2.3 Phase 2: Control Task Analysis

Control Task Analysis (ConTA) considers the recurring tasks that mappers would complete, and is the second phase of CWA. Rasmussen et al. (1994a) discuss work situations and work functions as two approaches to understanding activities and tasks. Work situations are reoccurring activities occurring according to the time and location at which they occur. Conversely, work functions are situations not constrained by the time or location at which they occur. Further decomposing activities into work situations or work functions is preferable. In contrast, Naikar et al. (2006) discusses that, *in some work systems activity is better characterised as a combination of work situations and work functions"*. This thesis takes the Naikar's definition in the approach to ConTA due to the changing spatio-temporal nature of community mapping.

#### 3.2.3.1 Contextual Activity Template

Naikar et al. (2006) discuss how CATs show work situations and work functions; Figure 3.4[2] diagrammatically represents their relationship. Work situations are shown on the horizontal axis and work functions are shown on the vertical axis. Circles show work functions and the box around the circles show the extent of where work functions can occur (as opposed to must) and the bars show which work functions typically occur in each situation.

In terms of mapping, the differing work situations could be discussions on what to survey in that day's activity, in the field mapping, editing, quality assurance, and functions would be specific points on mapping itself.

[2] Adapted from Naikar et al. (2006)

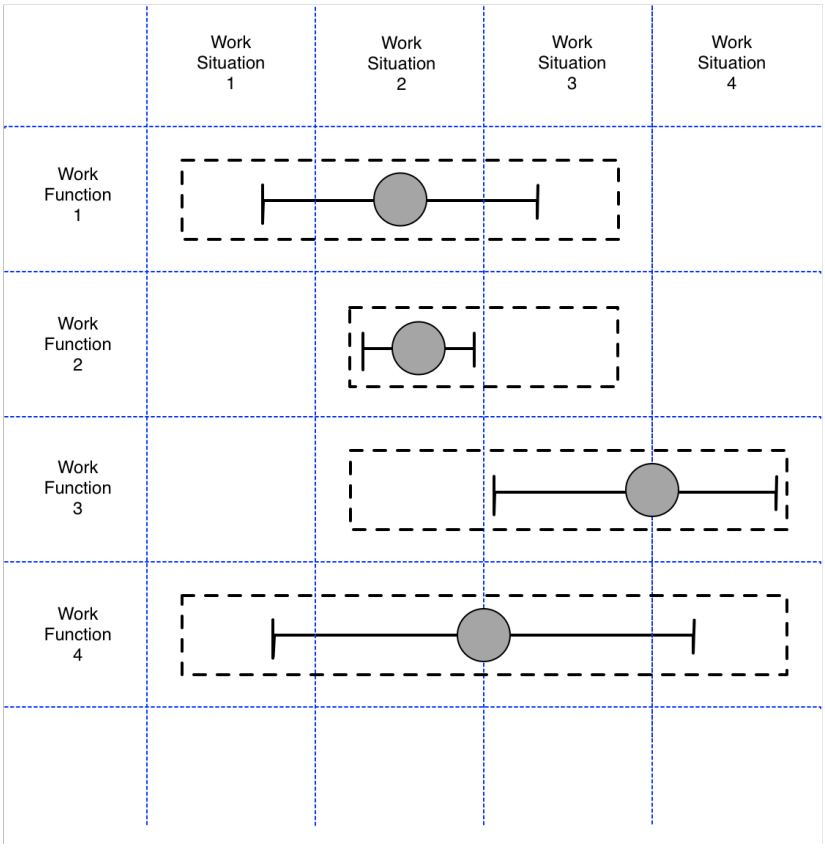


Figure 3.4: Contextual Activity Template

### 3.2.3.2 Decision Ladders

Decision ladders are used to consider activity in decision making terms (McIlroy and Stanton (2011)). This is useful to further decompose work situations and work functions activities.

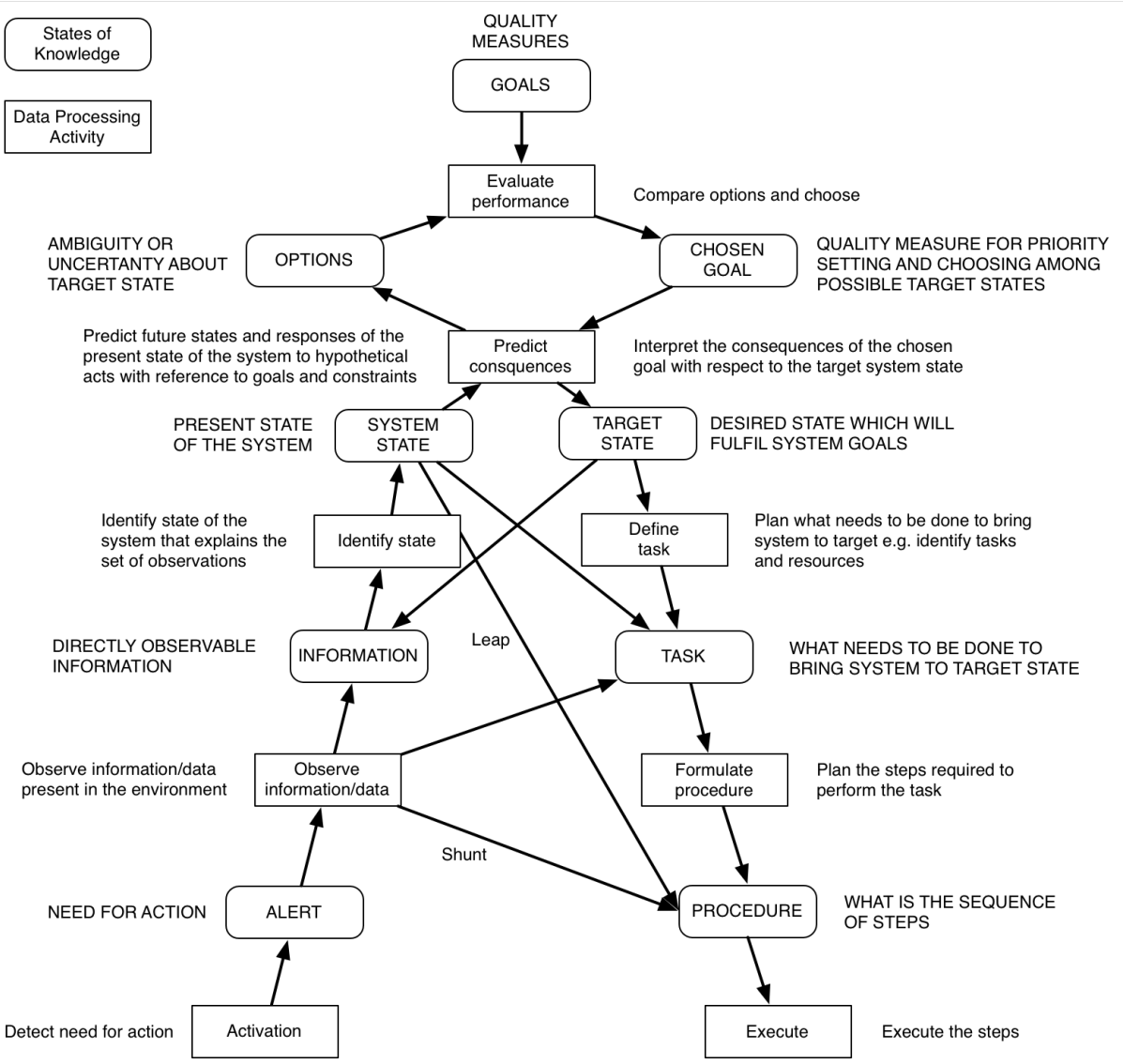


Figure 3.5: Decision Ladder

Figure 3.5[3] diagrammatically represents the decision ladder: Boxes represent information-processing activities and ovals represent the states of knowledge that are the outputs of these activities. The flow of information is representation by the arrows connecting the boxes and ovals together. The left side of the decision ladder is used to understand the current system state, whereas the right side is used to provide action to achieve the desired system state. Importantly, the start and end states of the decision ladder are flexible and do not need to be followed in a linear sequence; shunts and leaps allow transitions between states. For example,

[3] Adapted from Naikar et al. (2006)

more novice mappers are more likely to follow the entire ladder, whereas expert ones are often able to take shortcuts based on their skills and knowledge (Rasmussen and Jensen (1974)). Shunts connect information-processing activities to a state of knowledge whereas leaps connect two states of knowledge together âĂŞ inferring that two states of knowledge are connected and ultimately can lead to direct action.

For example, in certain situations the diagnosis of the system, here in mapping may lead directly to the execution of a set procedure. For example, a novice mapper on seeing a waterpoint not yet surveyed could take a geo-tagged photo, utilise a GPS to denote the location, or sketch it on a map prior to uploading to the database. An expert mapper would not have this decision process and would just execute their preferred action.

### 3.2.4 Phase 3: Strategies Analysis

The third phase of CWA, Strategies Analysis, *"addresses the constraints governing the alternate ways in which activities are conducted"* (McIlroy and Stanton (2011)). To contrast with ConTA that describes activities to be conducted, Strategies Analysis describes how these activities are performed. There are a multiple techniques of achieving the same result. This is summarised by Payne et al. (1993) who state *"decision strategies [is] a sequence of mental and effector (actions on the environment) operations used to transform an initial state of knowledge into a final state of knowledge where the decision maker views the particular decision problem solved"*.

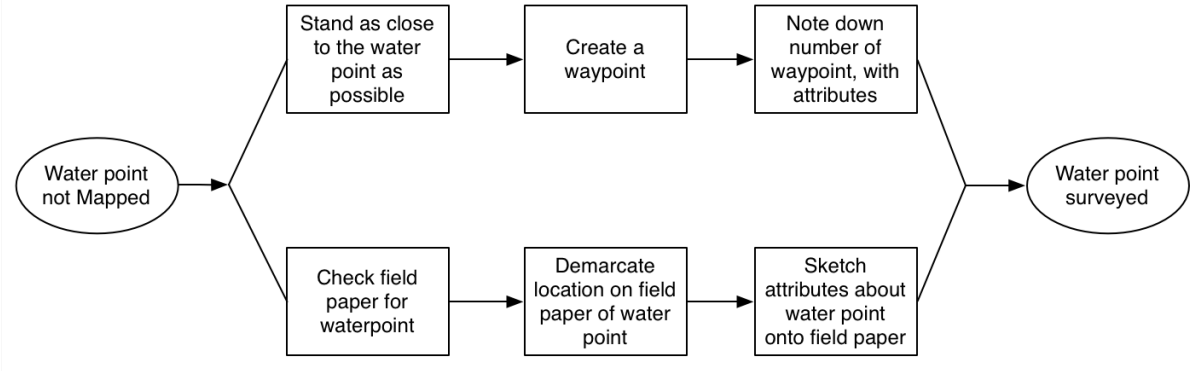


Figure 3.6: Strategies Analysis

For example, in mapping a water point, the mapper could utilise a GPS unit, a mobile phone or create a sketch. Each is an appropriate strategy for capturing the location and attributes of that water point, but each of the mappers has a differing strategy in accomplishing the task, this is an important factor in describing systems, which leads to the design of formative systems. Ahlstrom (2005) presents a method for diagrammatically representing strategies; this is adapted using the example of mapping a water point, diagrammatically represented in Figure

3.6. Ovals represent start and end states, whereas the boxes represent the specific tasks that the mapper would complete, dependent on their own strategy of work.

### 3.2.5 Phase 4: Social Organisational - Cooperation Analysis

The Social Organisational and Cooperation Analysis (SOCA), as phase four of CWA, examines the cooperation between actors within a system (McIlroy and Stanton (2011)). This requires adapting the CAT, and shading according to the classification of actor conducting the task. The resulting diagram is called a SOCA-CAT.

### 3.2.6 Phase 5: Worker Competencies Analysis

Work Competency Analysis (WCA) is the final stage of CWA and much like the title suggests, identifies the differing competencies of the workers. Rasmussen (1983) defines a model used by Vicente (1999); McIlroy and Stanton (2011) and others, which allows the investigation into a worker's competencies and the behaviour they use to effect work; this is called Skills, Knowledge, and Rules (SKR).

Vicente (1999) examines the differing components of SKR thus: Skill Based Behaviour (SBB) consists of the worker conducting automatic actions, based on the presentation of a work task, with little effort to understand the rationale of the task. Rule Based Behaviour (RBB) is where work is assisted by a set of rules and procedures, created by prior experience or instruction, which require thought to the ultimate goal of the work conducted; and Knowledge Based Behaviour (KBB) is a further extension of RBB, in the same way that RBB is an extension of SBB, where the worker needs to consider the principles of the task, based upon the environment and factors that influence that environment.

To further elaborate on these concepts to the mapping, in mapping a waterpoint, an implementation of SBB would be that a mapper notes down the location, without any supplementary information on a GPS. SBB would incorporate information about that point, as they know from prior experience that this is useful to edit. KBB would incorporate information such as the type of waterpoint, supplementary information and the decision of whether the tool being used to conduct the survey is appropriate.

### 3.2.7 Discussion

CWA will be used to create a conceptual framework for community mapping. This will help fulfil the aim of typifying community mapping through its decomposition as a socio-technical

system. One of the objectives of this thesis is to directly investigate VGI in IDCs directly, there is also novelty in producing a CWA in itself. McIlroy and Stanton (2011) notes that CWA is a process common in understanding military domains but is limited to understanding the first two stages of CWA, the approach taken for example by Lintern (2006) and Naikar (2009). In McIlroy and Stanton's approach, they claim in their rather mischievous title *"Getting past first base: Going all the way with Cognitive Work Analysis"* that within the literature CWA *"rarely get[s] beyond the first one or two phases"*. As this thesis examines in Chapter 6, it builds a thorough CWA of community mapping and discusses the implications of this novel work domain in Chapter 7.

Changing the work domain from a militaristic to a humanitarian domain is apt, as community mapping shares similar characteristics with military work domains. Localities in IDCs are dynamic environments, the workers share a common goal, but may have differing competency levels and may be unfamiliar with the environment. For example, ConTA, while being an established part of CWA with a large history still has scope for methodological guidance, providing the rationale for Naikar et al. (2006) to distil the concepts and guidelines for ConTA, specifically: *"The application of ConTA is, therefore, limited by the lack of a coherent set of theoretical concepts and methodological guidelines"*. They develop ConTA guidelines and a method, to be applicable for analysing other work environments other than a military one. A much longer discussion on the history and evolution on ConTA and other elements of CWA can be found in Rasmussen et al. (1994a) and Vicente (1999), though this is out of the scope of this thesis.

Ultimately in creating a socio-technical framework, the intention is to first describe then support workers with their work, not to prescribe how to conduct it, recalling the statement of Vicente (1999) in section 3.2 *"workers do not, cannot, and should not consistently follow the detailed prescriptions of normative approaches"*. This will not work for an activity such as community mapping, as inclusive projects do not treat their workers as cogs in a machine. By contrast, in the socio-technical system of community mapping, mappers are able to choose the strategy for affecting their work in a respectful manner, creating a formative, inclusive system. This helps prescribe the research approach, to first establish what is happening currently (the descriptive) and to inform the development of concepts that establish the formative. This ignores the normative, as prior to this thesis, there was no normative state of community mapping in developing countries to consider.

This key principle of formative design is further echoed through KBB, in that the worker has the responsibility to use their collective learning to create an outcome beneficial for the long term aims of the work, as opposed to RBB where the worker is effectively a cog in a machine, operating purely on a set of rules, without opportunity for interpretation. In community mapping, building towards a KBB approach for the community will be essential, due to the dynamic environment of IDCs; the community mappers will need to utilise their knowledge

of the environment and the tools available to create the map. This will also mean choosing the appropriate tool(s) to conduct the mapping.

## 3.3 Ethics

Researching alongside external, non-academic work presented its own difficulties, in both balancing the needs of research and *finishing* the work. At times throughout conducting research of this thesis, finishing the work that facilitated access to conduct research after the research investigations had been completed was an ethical necessity, though not a requirement of the work itself. This thesis will examine this statement in detail in Chapter 7, in discussing how the inception of mapping in Tandale (Chapter 5) and how these forays led to the construction of the conceptual framework. Now, alongside the write-up and completion of this thesis, this mapping has been scaled up to the majority of the urban conurbation of Dar es Salaam through the Ramani Huria project.

## 3.4 Thesis Audit

As a result of the previous sections on methodological selection and given the purpose of the thesis identified in the previous Chapters, this section presents an audit of the empirical studies within this thesis. This audit shows the broad empirical study area, the task and purpose of the research study and sample size of participants and briefly how they were selected. Additionally, this audit also provides the underpinning for the subsequent structure of this thesis and the approaches for addressing the objective of this thesis and ultimately its Research Question.

The structure of this audit and the empirical chapters of this thesis are built around the concepts of Normative, Descriptive and Formative, discussed earlier. Chapter 2 has established that there is scant evidence on how community mapping should/could work, in effect providing the gap in research for this thesis. A descriptive approach should first be taken to describe community mapping, and requires a suitable method to do this. Upon the work domain being suitably described, a formative approach is used to create the conceptual framework of this thesis, using Work Domain Analysis. Table 3.1 describes the purpose, participants and method used in this thesis' case studies, it is also discussed in detail in this section.

| Study | Method | Task/Purpose | Sample Size |
|---|---|---|---|
| Scoping Study | Experimental | Scoping analysis of crowd sourced data prior to the start community mapping and during. | n/a |
| Community Mapping | Observer as a participant | Community mapping of Tandale | 40 |
| | Interviews | In depth interviews with participants and stakeholders about the Tandale experience. | 7 |
| Community Mapping: Redux | Participant as an observer | Mapping a sub-ward of Tandale. Observing the process of community issue prioritisation, leading to mapping a sub-ward along community identified challenges. | 15 |
| | Interviews | Post interviews covering in depth the process and reflection of community mapping. | 8 |

Table 3.1: Empirical Studies Undertaken Within This Thesis

The interviews are then codified, the themes are discussed later in this thesis.

### 3.4.1 Scoping Study

The following aims and objectives were investigated through the scoping study: Research Objective 1: "**Examine the characteristics of VGI quality in IDCs**". This has the further aims of:

1. Examining the extent to which community mapping been used previously in other environments and contrast with the emergence of community mapping in Dar es Salaam;
2. Interrogating the quality of VGI data produced by community mapping. Purpose

This scoping study examined community mapping as a data collection activity, finding that scarce data existed within the community of Tandale, providing the opportunity for community mapping. Initial results frame the approach and results of the process of Community Mapping in Chapter 4.

**Theory** The standards of ISO:19157 are used to assess the quality of data, in a comparative approach between community mapping generated OSM data and Open Data released by the City Council of Dar es Salaam.

**Methods** This study is a longitudinal study covering the period of 2011 to 2015 - using a quantitative experimental methodology first used by Haklay (2010) for OSM and NMA data in the UK, synthesising differing methods related to ISO:19113, and its subsequent development ISO:191157.

**Sampling Strategy** The two data datasets that are compared are OSM and NMA data released by the City Council of Dar es Salaam.

### 3.4.2 Community Mapping of Tandale

This study supports Research Objective 2: **Examine the praxis and characteristics of community mapping in IDCs**

**Purpose** This builds upon the scoping study to further typify and describe community mapping. As such, the results of this study form a significant portion of Chapter 5 and addresses the following aims and objectives:

1. Examine the extent to which community mapping has been used previously in other environments and contrast with the emergence of community mapping in Dar es Salaam;
2. Interrogate the quality, processes and methods involved in community mapping, to understand the concepts of community mapping as a socio-technical system.

**Theory** Goodchild's theory of VGI frames this study, as the data produced by Community Mapping is inherently volunteered and geographic information. The participation of the community is also framed within Arnstein (1969) framework on the Ladder of Citizen Participation examined against previous theories on community mapping by Perkins (2007) and Peluso (1995).

**Methods** As the purpose of this study is to typify community mapping, this necessitates a mixed methods approach. This builds upon the deductive experimental approach of the scoping study, combing that with the research method of *observer as a participant* during an instance of community mapping and interviews with the community mapping participants. Semi-structured interviews were also conducted examining the community mapping event and the participant perspectives.

**Sampling Strategy** Participants were drawn from community groups and a local university, through engaging with community leaders. These roles will be expanded upon in the study. Building upon the results of the *observer as a participant*, participant roles were identified and a sample of the forty community mapping participants were interviewed. A further breakdown of their input is in Annex A, insights gleaned from participants and their role is also identified throughout this text.

### 3.4.3 Cognitive Work Analysis

This supports Research Objective 3: **Determine the constraints of the design space of community mapping in IDCs**.

**Purpose** This study utilises the results of the community mapping in Chapters 4 and 5, to build a framework of community mapping using Cognitive Work Analysis to determine the constraints of the IDC environment, presented in 6. The synthesis of these approaches results in a conceptual framework of community mapping in IDC in Chapter 7.

**Theory** Cognitive Work Analysis is a tool used to decompose complex socio-technical systems. It was first presented as a unified toolkit by Rasmussen et al. (1994a), extended by Vicente (1999) and refined by Naikar et al. (2006) to be applicable for analysing other work environments than a military one. With its characteristics of being a dynamic environment, this thesis utilises CWA as a method to understand the *design space* of community mapping.

**Methods** The approach of this study is to first build a CWA. This will require a change in the previous study outlined in section 3.4.2 moving from 'participant as a observer' to 'observer as a participant'. As with the previous study semi-structured interviews were conducted around the community mapping event eliciting the participant's experiences and thoughts about the

event. The comparison of these two studies will also allow the validation of the conceptual framework.

**Sampling Strategy** Participants were drawn from community groups and a local university, the same method as the same study, but with new participants. A further breakdown of their input is in Annex A, insights gleaned from participants and their role is also identified throughout this text.

## 3.5 Chapter Summary

This chapter has introduced the research methods employed in this thesis, focusing on two main areas: the nature of research and how CWA informs the construction of the conceptual framework. CWA is especially relevant due to being a tool that allows for the decomposition of complex socio-technical systems, such as community mapping. The thesis audit represents and reorders the research questions and objectives according to the empirical studies conducted by this thesis. Finally, a discussion on ethics was presented, intertwining the ethical standards of the University of Nottingham, with wider humanitarian goals. This chapter also effectively concludes the preamble of this thesis, with subsequent chapters being empirically guided.

# Chapter 4

# Scoping Community Mapping in IDCs

## 4.1 Chapter Introduction

This chapter is scoping a case study to examine and interrogate the quality of VGI data produced by community mapping. The following research objective guides this chapter:

**Examine the characteristics of VGI quality in IDCs**

This chapter is structured by one empirical section, a study of the data in Tandale, Dar es Salaam, prior and subsequent to an instantiation of community mapping. This grounds the theoretical implications of community mapping, toward reframing and examining the characteristics of community mapping as a socio-technical work domain, providing the rationale to conduct a descriptive study of community mapping in the subsequent chapter. This is guided by Research Objective 1, **Examine the characteristics of VGI quality in IDCs**.

## 4.2 Tandale: Dar es Salaam's Beating Heart

Dar es Salaam in Tanzania is representative of many challenges that cities across IDCs face, especially regarding access to maps. Administratively, the Dar es Salaam City Council (DCC) is the city authority that covers the metropolitan area of Dar Es Salaam, composed of three municipalities: Kinondoni, Ilala and Temeke. According to the National Bureau Statistics (NBS) the official statistics agency for Tanzania, these three municipalities are subdivided into 89 wards or *"Kata"*; these wards are then further subdivided into sub-wards or *"Mtaa"*. In terms of governance, each sub-ward has a sub-ward representative who deals locally with community issues, reporting to a Ward Executive Officer (WEO) who reports to the apparatus of the respective municipality.

This chapter examines Tandale, a ward of Dar Es Salaam. It is informally developed, unplanned, and is a very dense urban environment; roughly covering an area of 1.5km$^2$ it sustains a diverse population, being formally listed as having 54,781 residents. However, like most IDCs, formal statistics are potentially incorrect Lu et al. (2015): factors such as internal rural to urban migration and migration from conflict areas to stable urban centres potentially causing higher numbers in combination with poor statistical and institutional capacity of statistics collecting agencies.

In informal areas like Tandale, this figure has the potential to differ greatly: Robbins (2012), Mutisya and Yarime (2011) discuss a similar area in Kenya, Kibera, which has a variety of population estimates, from as high as 1.5 million to as low as 200,000, each from authoritative population sources such as the Kenyan Bureau of Statistics, UN-Habitat, the U.S. Government (a major multi-agency donor) to less authoritative organisations such as mass media and NGOs, and academic research; for example Desgroppes and Taupin (2011) investigated the potential in remote sensing for estimation of population density. Even at the low end population of estimate 200,000, this is still a significant population density in area of 3km$^2$; amplifying the difficulties and challenges in the provision of statistics and data collection in informal settlements. For Kibera, this is made even more impressive in that Kibera is one of the most studied and researched slums in the world with an exposure that far surpasses others like Tandale raising the question, if the situation is as challenging and complex in areas with Kibera's global profile, what about those without the spotlight of global awareness and focus?

Tandale is critically important to Dar es Salaam's wider population: with one of the city's main markets located in its boundary. Tandale market acts as one the main points in the city for the distribution for grain, fruit and other foodstuffs (Figure 4.1) alongside local resellers of a plethora of goods from clothes, electrical items to beds (Figure 4.2). This is mixed with residential areas, housing the populous of Tandale, with roads and pathways squeezed in-between tightly packed buildings where the energetic, loud and ubiquitous piki pikis (motorbike taxis) and bajajs (rickshaws) compete for space with dala dalas (public buses), cars and pedestrians.

Figure 4.3 and Figure 4.4 demonstrate the density of Tandale's urban environment and the implications/effect of informality of public infrastructure, such as the open drain in Figure 4.4. This contrasts with the numerous antennae and electrical lines shown in Figure 4.3. Tandale's urban landscape is one which is constantly changing and evolving through many factors. Part of this change is due to increase of population across the city but part is due to Tandale's susceptibility to flooding and other natural hazards. This impacts the ward in numerous ways, primarily through the deaths of residents and the destruction of their property, as evidenced in Figure 4.5.

Natural hazards like this are unfortunately a common occurrence in Dar es Salaam and have much wider implications post the initial event. Flooding increases the population of mosquitos,

Figure 4.1: Tandale Fruit, Vegetable and Grain Market

leading to a potentially higher infection rate of mosquito borne diseases, such as Malaria (Caldas de Castro et al. (2004)), Dengue (Trpis (1972)), and other diseases. To construct empirical studies into epidemiology, data that represents the local environment in maps needs to exist, and in part is evidenced by published research, but in all cases its origin is not referenced nor defined: accessibility of data is a challenge.

## 4.3 Case Study One: Scoping Study

This case study is an examination of data available prior and post community mapping, then compared with an authoritative data released by the DCC. This approach quantitatively assesses the map data, with subsequent sections investigating how such data was produced. This stage is augmented via discussions and interviews with ward officials and participants in community mapping, aimed at eliciting the extent of access to maps and geographic data and the characteristics in this IDC environment.

Figure 4.2: Tandale Goods Market

Figure 4.3: Building Density and Informality in Tandale, August 2011

### 4.3.1 Method

Previous research in VGI has primarily focused on the quality of the data. Haklay (2010b) presents a methodology for the comparative assessment of VGI data, following ISO:19157: Geographic Information - Quality Principles. Mooney et al. (2011) and Barron et al. (2013) further the quality analysis of VGI, proposing analysis of the intrinsic factors of the data, such as metadata and attribution when no such comparative dataset exists. As a comparative dataset became available, this approach is taken.

This quantitative approach is augmented by a qualitative approach, specifically semi-structured interviews. The participant responses were anonymised in accordance with the ethical framework of the University of Nottingham. The transcripts of these interviews are in Annex A. These interviews were conducted in September 2011, relating specifically to the progression of a community mapping project in Tandale, during August - September 2011. These interview transcripts are further supplemented by public interviews with ward officials, available due to citizen media and generation of non-geographical content (such as blogs, videos and photographs) this will be discussed in-depth in the subsequent chapter.

Figure 4.4: Density of Buildings, August 2011


Figure 4.5: Tandale Post December 2011 Flood Damage

### 4.3.2 Research Approach

Here the temporal period of this case study is important, due to the progress of change that has occurred in Tandale and across Dar es Salaam since the start of this thesis. Figure 1.2 showed Tandale as it existed in OSM as of August 2015. Figure 4.6 shows Tandale (as rendered in OSM) prior to community mapping. There was practically no data in 2011. Authoritatively produced sources such as government produced maps were not accessible at this local level; this was the same for other professional mapping providers such as Google, Yahoo and Nokia's map professional map offerings/products. VGI sources, such as Google Map Maker were in a similar situation, evidenced previously by Figures 1.9 and 1.10.

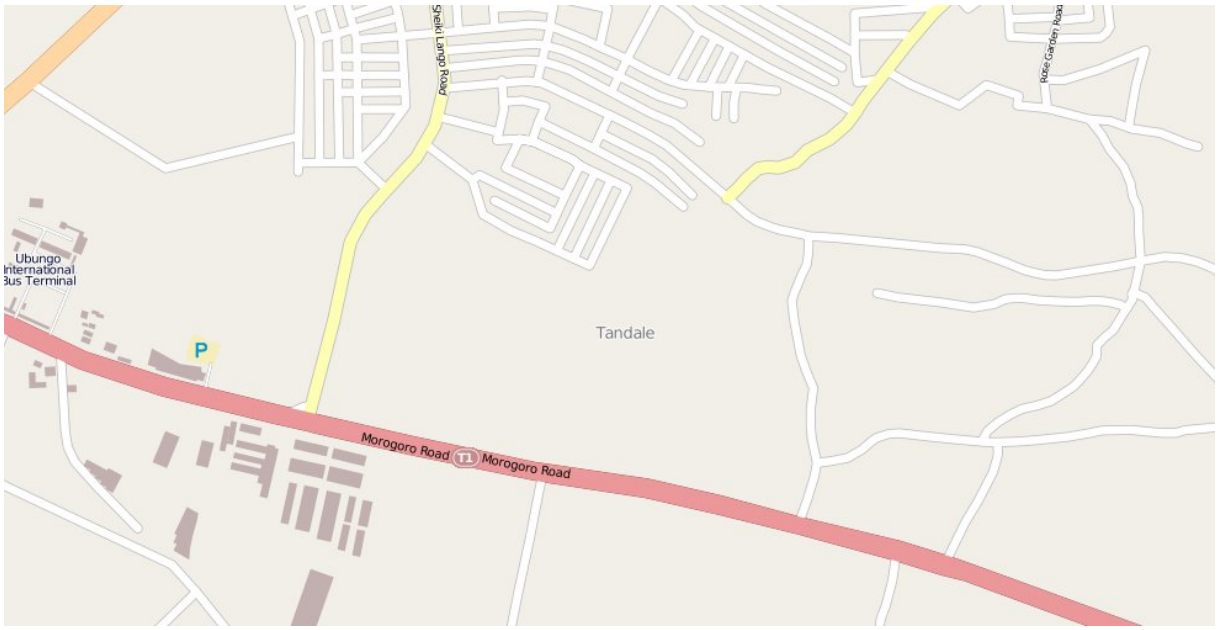


Figure 4.6: "Tandale" prior to commencement of community mapping in OSM

The sole data provider with accessible data on Tandale was OSM, however, the location of Tandale wasn't labelled correctly as Figure 4.6 demonstrates[1], with Tandale actually a kilometre east, within the triangle of roads, the location of the Tandale tag, was actually Manseze, another ward with similar demographics to Tandale, but administratively different. The map of Figure 1.3 was generated once the location and extent of Tandale was established. This demonstrates the severe lack of data available for such a populated area.

Due to the lack of data upon starting this research in 2011, but with significant data for analysis available in 2013, a longitudinal study approach was taken, covering the period of 2011 to 2013 . Through this approach, VGI and Authoritative data can be comparatively assessed: this is due to the DCC seeing the results of community mapping, releasing some map data openly in June 2012 almost a year post community mapping. The administrative boundary of Tandale

[1]The distinctive triangle of Tandale is to the right of the image.

was provided by NBS. The provenance of data and implications of its access will be discussed later in this thesis and as part of a wider exposition of comparative data quality for the city of Dar es Salaam in Annex A.

In part due to the deficiency of data available for quantitative analysis, but also due to the emergent nature of the environment in which community mapping in IDCs occurs, a mixed methods approach is necessitated. The constraints and gaps in knowledge also help inform methodological approaches to inform the praxis of community mapping in IDCs.

### 4.3.3 Data and Quality

The geographic data used in this study is topological road data, collected from OSM and the DCC, acting as VGI and Authoritative data sources respectively. Only road data has been released and is available for comparative analysis. Comparing topological road networks is a commonly researched area of VGI quality analysis as discussed by Koukoletsos (2012) and others in Chapter 2. In line with ISO:19157 and the constraints of data, the quality attributes of completeness, spatial accuracy and fitness for purpose were assessed. The factors behind the selection of these two quality attributes will be discussed later within this section.

The OSM data was downloaded from GeoFabrik.de as an .osm download on the 30/12/2012 with the road network for OSM identified through selecting roads with a *"Highway"* tag. The authoritative data was provided as Open Data by the DCC. This data was released to the public on the 15th of June 2012. There is no quality assessment of this data, or analysis of how it was generated. It is considered authoritative due to the provenance of the authority (namely the DCC) that has released it. The data itself was created through the digitisation of ortho-rectified imagery, collected in 2005 and subsequently used by the DCC GIS department for internal map creation for property rates management. Through conversations with the data manger of DCC it was established that this data has not been updated since its initial digitisation in 2005/2006.

### 4.3.4 Procedure

To assess positional accuracy, the method of Goodchild and Hunter (1997) is used. A 10m buffer is created around the authoritative road network. 10m is used as a buffer due to Ramm et al. (2011) finding that positional accuracy of 5m is sufficient (p30), hence a buffer of 5m each side of the centre line. OSM data was then clipped using this buffer and the sum of the line length calculated by totalling the collective length; percentages were calculated by dividing by the length of the OSM data.

To assess completeness, Haklay et al. (2010) method comparative approach is used where the sum of road lengths in each dataset is compared. A grid then is superimposed upon the respective road networks of a resolution set by the researcher. Haklay et al. (2010) used a spatial resolution of 1km$^2$, however due to this the much smaller area being assessed (a ward, as opposed to an entire country) the resolution for this grid is 100m$^2$; any smaller would be counterproductive, due to the level of detail in the datasets being analysed.

Assessing fitness for purpose depends on the usage for which you need the data; it is a subjective metric. Girres and Touya (2010), describing the need for quality specifications for VGI quality, show how OSM data could be used for navigation, denoting that this is predicated on other quality metrics, where *"lack of completeness, as attribute accuracy, would cause errors that are hardly acceptable"*. The same applies to metrics such as logical consistency and positional accuracy. Mooney et al. (2011), discussing the fitness for purpose of metadata, building upon Bulterman (2004) suggestion that the *"complete disregard for documentation of data resources has made it almost impossible for one to perform a fitness for use/purpose evaluation on data resources"*. These differing cases indicate the subjectivity of assessing fitness for purpose, as such fitness for purpose is approached qualitatively through examining the state of mapping prior to community mapping and eliciting responses from those who use such maps.

## 4.3.5 Results

### 4.3.5.1 Positional Accuracy

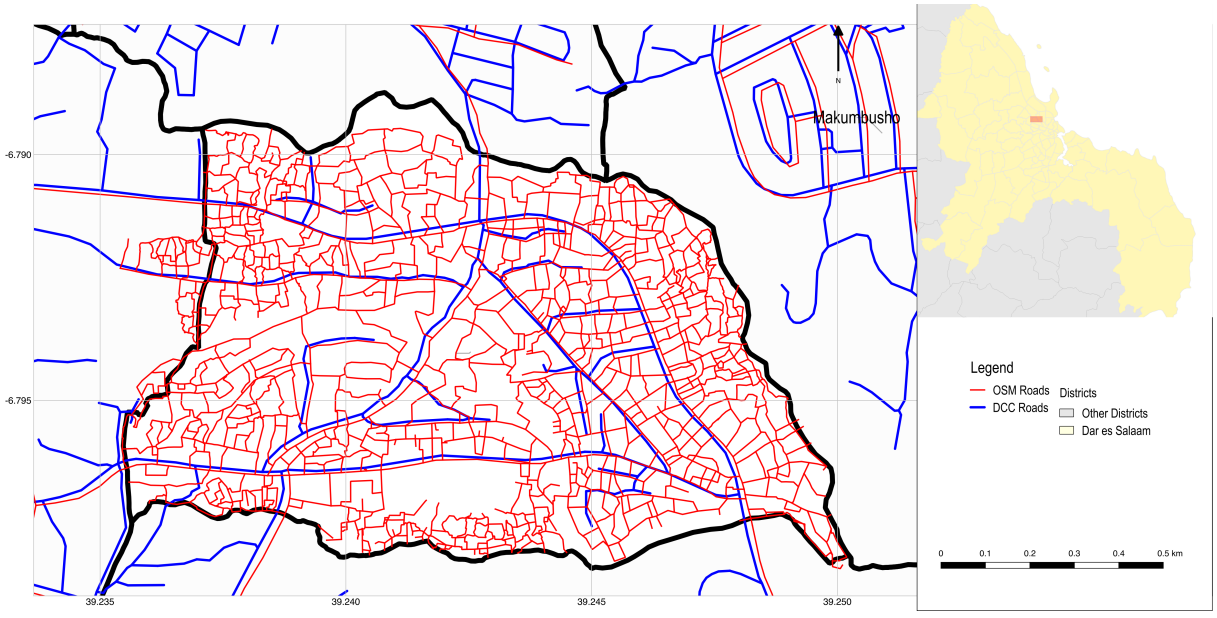


Figure 4.7: Analysis of Positional Accuracy of VGI and Authoritative Data

Figure 4.7 details the OSM and DCC road networks for Tandale ward, the extent of its administrative boundary being shown in green. The red lines demarcate the road network in OSM and the blue lines demarcate the road network of DCC. In terms of positional accuracy, 100% of OSM road network is within a 10m buffer of the DCC roads, and is therefore of a higher positional quality.

#### 4.3.5.2 Completeness

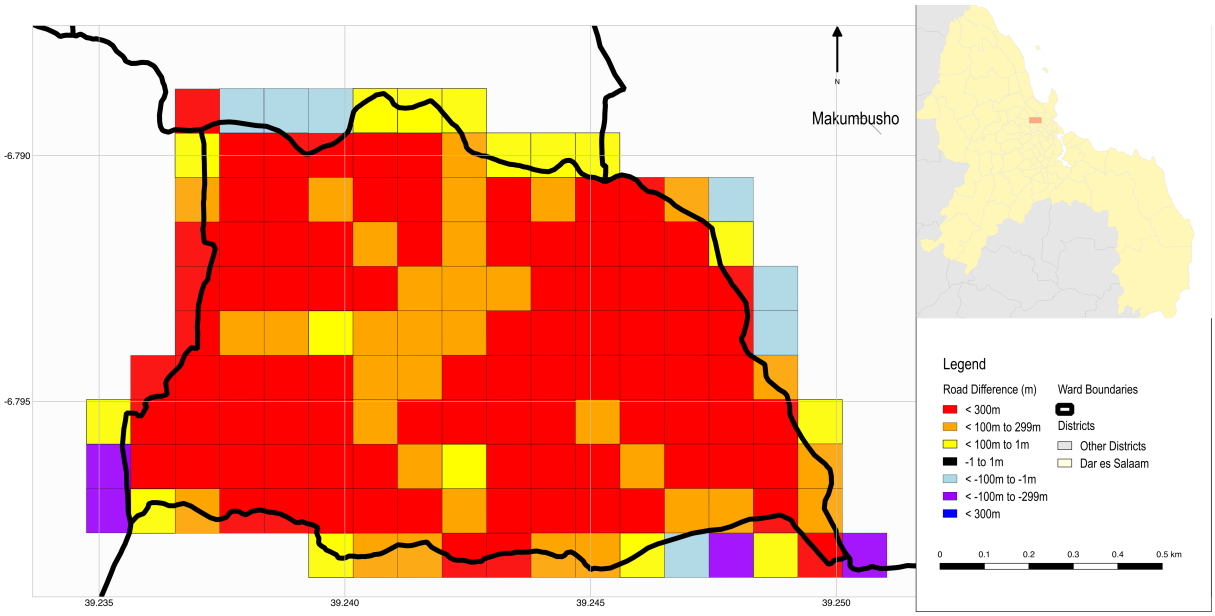


Figure 4.8: Range of completeness in data between VGI and Authoritative Data

Figure 4.8 shows the assessment of completeness for Tandale (VGI denoted as Red and Authoritative Data as Blue), with completeness of data in Tandale heavily biased towards the OSM data, and by extension the data collected during community mapping. As such, the OSM data is of a better quality, when considering its completeness compared to the DCC data.

#### 4.3.5.3 Fitness for Purpose

The quantitative approach used in the previous sections' demonstrate comparative features in the metrics of completeness and positional accuracy, though without an understanding of the map purpose, conducting such analysis is purposeless. To understand fitness for purpose, semi-structured interviews and public interviews are used to elicit an understanding of this quality metric.

The map that was being used for decision making and other functions of the Ward and its Mtaas is shown in Figure 4.9. The map's origin was unknown to the ward's staff, it being

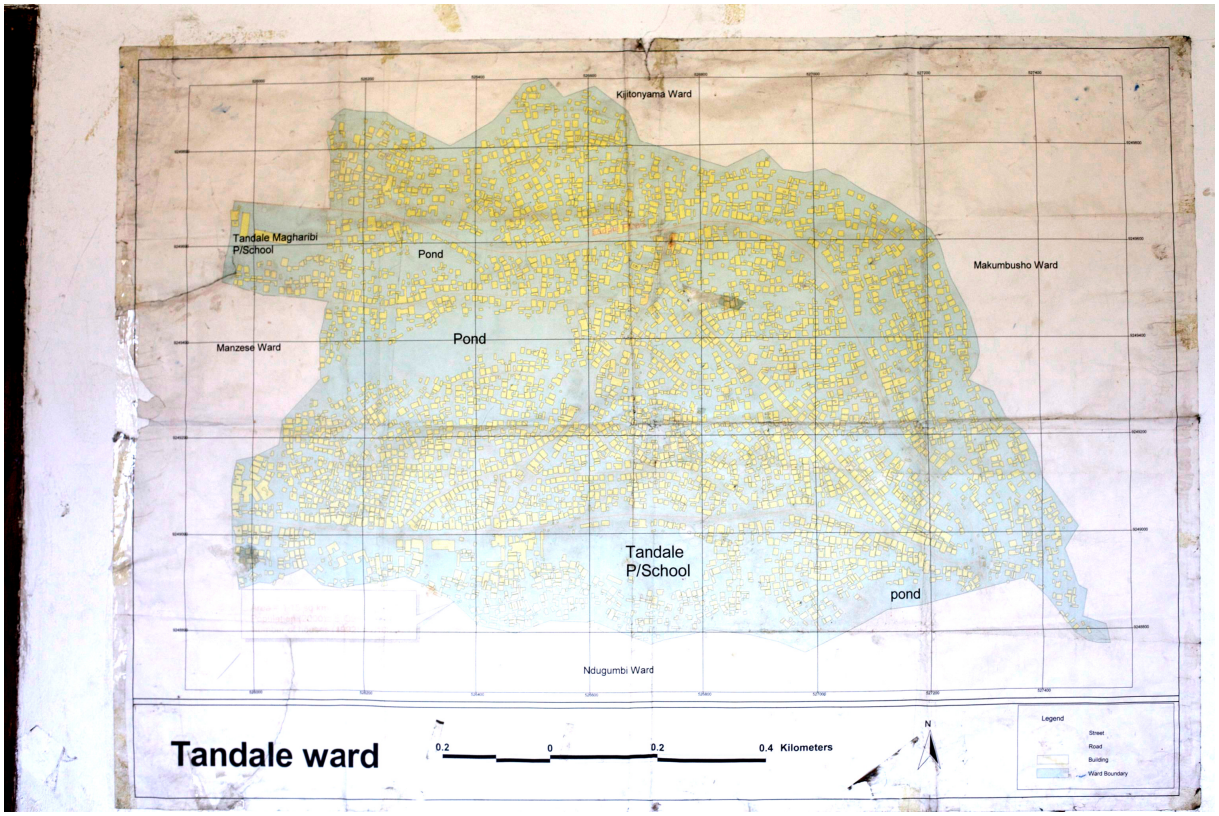


Figure 4.9: Ward Officer's Map of Tandale, Pre Community Mapping

a remnant from previous staff who had acquired it for a now unknown reason[2]. This lack of its purpose was compounded with no information on who produced the map, its lineage, method of data collection and other essential features such as coordinate system.

After the mapping, which in part helped generate the map shown in Figure 1.2, a public interview was held with one of the ward officials, the *Mtaa Officer* for Sokoni Mtaa. This official is the senior representative of the *Mtaa* for tasks such as granting planning approval.

> *"The mapping helped because we had an official map with few features, now it is lots of features. This map has brought a deep insight to our community. In the community the mapping gave them something they never had before- For instance, the citizens have a problem of informal building. We spoke to them when building during the mapping. Mapping roads and paths puts us on the map and makes us aware of of features so we can build formally with this survey. People now know, this is where roads and paths should be, don't build on them"* - Sokoni Mtaa Officer Community Mapping Dar (2011).

At the local level, for the Ward Officers of Tandale and its *Mtaa*, this has had severe implications in terms of access: in that they are not using the best maps available. This is further

[2]This also signposts the need of handing over such works for future government officials and community members.

evident when examining the state of OSM prior to any community mapping activity. While the granularity of data is not as deep as the map currently, this data was freely accessible for anyone who wished to use/download it. Through participating in the community mapping, the wider community of participants from individual community members to government officials were shown the mechanics of freely accessible Open Data: OSM - *"We now know things we never knew, through the mapping we found these things out"*, Sokoni Mtaa Officer Community Mapping Dar (2011). This process of exploration was not limited to government officers, but was a common theme running through the participants [sic] *"having the other member assisting- at the end we came up with a good map, a speaking map, that speaks for itself"* - (Catalyser:7).

### 4.3.6 Discussion

The results of these three experiments to assess the comparative quality, is surprising in that the OSM data (representing VGI), collected through community mapping is of a higher comparative quality than the DCC data (representing authoritative data). This is contrary to initial research into VGI quality in the UK Haklay et al. (2010), Koukoletsos (2012), Germany Zielstra and Zipf (2010), Neis et al. (2012), France Girres and Touya (2010), Graser et al. (2014) and others that compare VGI data with an authoritative one, provided by an NMA. The sole exception is Koukoletsos (2012) when comparing the quality of two VGI sources together, namely Google Map Maker and OSM, although during a crisis mapping event - the Haitian earthquake where data was collected mainly via volunteers collecting through digitising aerial imagery, not through community mapping. Ultimately, the analysis of geospatial data quality of Tandale allows the conclusion that VGI data for Tandale post community mapping is of a higher quality than the authoritative data in stark contrast to the data environment prior to the community mapping where no data was available.

Continuing with this line of research, due to this data scarcity, investigating VGI data quality in IDCs would be severely constrained. It is possible to assess the quality of the data as others have done, but there is comparatively little novelty in this approach, bar applying a now tried and tested method in a different, albeit interesting locale such as the IDC of Tanzania. However, the novelty and findings of this scoping study, in that VGI can be comparable (if not of a higher quality in IDCs) to IACs, illustrate the challenges that exist in intersection of this socio-technical system of mapping in IDCs. The process of conducting this scoping exercise has led to the following findings/challenges, namely:

- Maps and map data are hard to get in IDCs: the findings discussed in section 4.3.5.3 reinforce the view of Baker (2011) in their experience of collecting data to investigate the urbanisation of Dar es Salaam and others discussed in Chapter 2.

- The IDC domain necessitates a different approach: O'Neill (2000) postulates that research in IDCs has different characteristics when compared to research in IACs. This is exemplified through prior geographic research that focuses on the quality of VGI in IACs at comparatively large scales: either at a city or country level. The lack of data coverage prior to Tandale's community mapping is replicated across Dar es Salaam, rendering any such large scale analysis impossible, but it is done relatively easily in IACs as discussed in section 2.3.3.1. In the assessment of quality post community mapping at a ward level (1.5km$^2$), the authoritative comparative dataset is lacking, validating the views of Mooney et al. (2011) and Barron et al. (2013) on the need to research methods that investigate the intrinsic quality of a VGI geographic dataset. This points to VGI being a good candidate for map data in IDCs.

- There is a lack of knowledge and awareness that such data exists within government and other holders of data. The view of this thesis that the institutions and government generally do not wish to maliciously hide data: they just unaware of the value and effect that the existing authoritative data that they have can have on the wider data ecosystem. The Tanzanian Government Open Data policy document, GoT (2013) discusses that there are institutional challenges to opening up data through the OGP program of Tanzania *"given the size of the country, it has been difficult to disseminate, popularise and domesticate the OGP programme comprehensively to grass root levels"*. This is personified by the DCC data release with the statement that releases this data openly: *"we would like to share with the community and other stakeholders [sic] in improving the mapping of Dar es Salaam, we hereby release this dataset into OpenStreetMap or any similar open platform"*. Additionally, the challenge of data access is echoed across published literature with some research demonstrably utilising access to data, not in the public domain or public knowledge. The provenance of such data could be questionable, but this thesis advocates that some data is better than no data.

- Notions of authoritativeness are challenged: Haklay (2010b), Koukoletsos (2012),Zielstra and Zipf (2010), Neis et al. (2012)), Girres and Touya (2010), Graser et al. (2014) all compare VGI with an NMA dataset with the implication that NMA is of a higher quality: here the VGI, which once assessed is of a higher measurable quality compared against the authoritative dataset whose provenance is potentially questionable due to factors such as undocumented production methodology and its remaining relevance in the fastest growing city in Africa whose urban landscape is rapidly evolving. Goodchild (2007) suggested that *"the most important value of VGI may lie in what it can tell about local activities in various geographic locations that go unnoticed by the world's media, and about life at a local level"*. Haklay et al. (2010) in response to this statement comments with reference to *"rural and poorer areas"*:

> *"the evidence is that places that are perceived as 'nice places', where members of the middle classes have the necessary educational attainment, disposable income for equipment and availability of leisure time, will be covered. Places where population is scarce or deprived are, potentially, further marginalised by VGI exactly because of the cacophony that the places which are covered create".*

Tandale, and the other 70% of the unplanned and informal areas of Dar es Salaam would easily fall under this remit, however the map shown in Figure 1.2 would disagree with Haklay's 2010 contradiction of Goodchild (2007) on VGI. This demonstrates that VGI in IDCs can be comparable using accepted methods of quality assessment, but also through validation by local government officials, evidenced in section 4.3.5.3.

The culmination of these factors is simple: A new community mapping method is required. Haklay (2013b) in discussing the nature of the rise of democratising movements such as VGI in the mapping of informal settlements states: *"the act of creating map is a political intervention in making the place visible and there the act of creating it goes beyond the practical humanitarian benefits of having as map"*. As evidenced by 1.3, there is a need for map data for Tandale - there wasn't a map in 2011 and this is representative of other communities in Dar es Salaam and others like Tandale globally. This map shouldn't just cover roads, but be an accurate reflection of the on-the-ground reality, but the methodology of such community mapping is poorly understood, with brief descriptions on the method of community mapping from Hagen (2011) combined with existing methods of analysing VGI insufficient to analyse such data. In IACs, VGI datasets are comparable to those produced by NMAs. IDCs are not as fortunate, existing in scarce geographic data environments. While VGI currently is vying to break the hegemony of NMAs and Authoritative geospatial data providers in IACs, there is the opportunity in IDCs to examine a new method of creating maps, through the communities that live there.

This view is reinforced through assessing the quality of this data, though it is one component of this socio-technical system. NMAs are guided by legislation, that define and regulate the outputs of an NMA. For example, in assessing the positional accuracy of VGI and authoritative data in the UK, Haklay et al. (2010) referenced Hansard (2003), the official record of the UK Parliament which has enshrined the road widths of the UK in law, to calculate the centre line for the buffer for the authoritative dataset, subsequently using Goodchild and Hunter (1997) method of positional accuracy assessment. No such guidance exists in Tanzania. Other factors, such as data sharing can also be considered in this manner. Simply assessing the quality of data in IDCs is not useful in itself: **the gap in knowledge is in understanding community mapping as a socio-technical system, as opposed to the functions of this system like data quality and how such data is shared**. This doesn't imply that this is impossible, Figure 1.2, a community generated map of Tandale demonstrates that maps of IDCs can become available,

*but how?*.

## 4.4 Chapter Summary

This chapter examined the origins of community mapping and how it has been used previously, framing Tandale as a location of research, additionally illustrating and advocating the need for an alternative view of community mapping in IDCs. This will be investigated in the next chapter.

# Chapter 5

# Community Mapping: Ramani Tandale

## 5.1 Chapter Introduction: Introducing Ramani Tandale

The previous chapter examined the characteristics of community mapping in IDCs and introduced Tandale as the location of study. This chapter specifically investigates the praxis of community mapping, through a field study examining community mapping as a socio-technical system. The name of *"Ramani Tandale"* is specifically important: *"Ramani"* is Swahili for map. Hence, *"Ramani Tandale"* means the map of Tandale. The name was chosen through discussion in an open forum, by Tandale's community, whose nature will be discussed with relevance to community participation and mapping.

Well established in IACs such modes of production are not known in IDCs. As a first step to understanding community mapping as a socio-technical system, this chapter examines why this is the case via a case study of community mapping in Tandale which started in August 2011. This is guided by Research Objective 2, **Examine the praxis and characteristics of community mapping in IDCs**.

## 5.2 Theoretical Approach

Haklay and Weber (2008) charted the progress of both registered contributors and edits to OSM, from its inception in 2004 to 2008, the community forming from an idea of Steve Coast and then growing to over 40,000 users in that time period. Since 2008 the community using OSM has grown exponentially, currently standing at 3 million registered users working as a global community and with Tandale's community now contributing to this global community. Wenger (1998) provides a theoretical framework to define this grouping of stakeholders, where they are termed as a *"community of practice"*. Specifically, *"communities of practice are*

*groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly"*. Despite grouping people together, there will always be clear differences in community, with many levels at a global and local level, each with differing levels of participation. Haklay et al. (2010)) discuss this phenomenon, noting the lack of data in deprived areas in the UK, and there are perhaps parallels with those communities and the one existing in Tandale. *"How can the participation of these communities be assessed and what are the implications?"*.

The theoretical framework of Arnstein (1969), in the form of a ladder (this was discussed in detail in 2.4.3 and has been grounded in public participatory geographic projects by Tulloch (2008) and Ganapati (2011). Conceptually, the ladder has eight rungs, where the bottom rung is where communities are *Manipulated* and coerced into participation in contrast to the top of full *"Citizen Control"*. The intermediary rungs chart the progression from non-participation to to full participation. Understanding the levels of participation potentially offer an opportunity to resolve the challenge of scarce authoritative data, if the production of the data is conducted *by* the community, *for* the community. This will be discussed later.

Finally, this case study is informed by descriptive pieces such as Naikar et al. (2006); Houghton et al. (2015); Parker et al. (2013) and Gerlach (2015) with the aim of *describing* the socio-technical system of community mapping. In the following chapter, this supports the investigation towards a formative socio-technical design for community mapping.

## 5.3 Method

Researching an environment such as Tandale presented a rare opportunity for investigating a novel professional and research topic combined with Tandale's complex environment and constraints of the research into this emergent field. As such, a mixed methodological approach was chosen. The *"Observer as a Participant"* method Gold (1958)), Robson (2011) and many others was chosen for the observation method of community mappers. This was guided by the theoretical approaches of understanding PPGIS described by Chambers (2006) and McCall (2003).

An extensive set of field notes were taken throughout the mapping and are publicly available as blogs that contain progression reports, photos of mapping and videos of the case study's day to day events. These notes are augmented by semi-structured interviews with community participants, undertaken one month after the *end* of this phase of mapping.

In approaching the investigation of community mapping in such a manner, the author participated (for parts, directing the community mapping efforts, allowing observation as a participant while, also being immersed in Tandale's environment). This cross-sectional approach

allows for a description of the socio-technical system of community mapping to emerge as part of this opportunistic process, specifically resolving the *roles*, *method*, *rationale* and *tools of community mapping in IDCs*.

## 5.4 Describing the Mapping of Tandale

### 5.4.1 Building Alliances, Teams and Community

What is the *community* in community mapping? So far, this thesis has focused heavily on the *mapping* component of community mapping. This subsection introduces the communities of Ramani Tandale as a community mapping project, the roles of participants, how they interact, their background, motivations, and ultimately, investigates how they participate and contribute.

### 5.4.2 Building Institutional Alliances

A point of discussion in Chapter 7 will be to examine the relevant factors for communities to become self-starting and sustaining in community mapping. However, Ramani Tandale was initiated by actors outside the community of Tandale, ultimately *for* Tandale but originally not *by* Tandale's local community. Two statements are key to understanding the inception of Ramani Tandale:

- *"[There was a] request from Ardhi University to allow students to make better use of their industrial placement, giving better skills and to apply those skills to directly to projects."*- (Organiser:2).
- Anderson (2013) retrospectively discussing the rationale for community mapping in Tandale states *"Tanzania lacked experience in low-cost and user-friendly infrastructure mapping and crowd-voicing tools to generate much needed good governance data. With the help of the World Bank, Tanzania participated in a knowledge exchange with Kenya, which had successfully used these strategies in Nairobi [Map Kibera]". This approach led to one of the organisers commenting: "[we are interested] in revitalising urban infrastructure (roads, streets, drainage, water points, solid waste collection) so we started a conversation about how to use this [Map Kibera] methodology to deliver public good to residents of Dar Es Salaam?"*- (Organiser:3)

The combination of these statements led to the World Bank initiating what became Ramani Tandale, with one of the organisers commenting:

> *"My job was to bring these partnerships together and put together the program and timeline for how this will be implemented, ensuring it is tied to the public good... prep[aration ]for the Dar Metropolitan Development Project, an investment the World Bank is making with the [Dar es Salaam ] City Council. The goal was to prepare geospatial information for it's implementation"*- Organiser:3

This was the framing through which the partnerships for Ramani Tandale were brought together. The stakeholders, institutional mission and brief role in Ramani Tandale is discussed here:

**The World Bank** is a global institution with the mission to *"End extreme poverty by decreasing the percentage of people living on less than $1.25 a day to no more than 3% and promote shared prosperity by fostering the income growth of the bottom 40% for every country"* - The World Bank (2014). It is one of the institutions created as part of the Bretton-Woods agreements to aid in the stability, reconstruction and development of the global economy, operating as a partner institution to the United Nations. The World Bank Institute funded the Ramani Tandale project as part of the South-South knowledge exchange program. "South-South Facility" is aimed at allowing programs and initiatives originating in countries from the Global South be shared to other Global South countries, facilitating knowledge exchange drawing on the prior expertise of development projects. Operationally Ramani Tandale was managed through the World Bank's Global ICT, Education and Urban Sectors. The World Bank aided with the funds, logistics, facilitation and dissemination of the project results.

**Twaweza** is an East African NGO which means *"make it happen"* in Swahili. They are a civil society organisation focused on being an enabler for effective and transparent governance. Twaweza supplied the funds for the equipment for the project.

**Centre for Community Initiatives (CCI)** is a Tanzanian NGO working within slums within Dar Es Salaam, focusing on community engagement and capacity building, such as installations of toilets and water taps. They facilitated introductions and the subsequent participation of six members of a Tandale women's group and spread awareness of the community mapping through their community network.

**Map Kibera Trust** has the mission of *"making the invisible visible"*, having started in the Kibera slum, Nairobi, Kenya. It conducts its mission statement through community mapping programs, mainly in Kenya in the slums of Kibera, Mathare and Mukuru; it was formed out of the Map Kibera community mapping project detailed in Chapter 2. As of 2014 it is the locally run custodian of the Map Kibera project, aimed at citizen mapping, citizen media and citizen advocacy. Map Kibera Trust contributed two community facilitators, both with prior community mapping experience.

**GroundTruth Initiative** has the mission statement: *"Helping communities use digital media,*

*mapping, and open data tools for greater influence and representation in development and democracy"* [sic]. GroundTruth was started in 2010 as a company composed of the originators of the Map Kibera slum mapping project. GroundTruth supported the creation of the Map Kibera Trust and subsequently Ramani Tandale through the provision of a community engagement advocate and project manager.

**Dar Es Salaam City Council** is the central government authority for Dar es Salaam and formally facilitated engagement of the Ward Executive Officer (WEO)[1] and their staff.

**Ardhi University's School of Urban and Regional Planning (SURP)** is a university and department with a campus in Dar Es Salaam, focusing on education and research on land and the environment. *"Ardhi"* in Swahili is translated as "Land". The School of Urban and Regional Planning (SURP) has a 4-year degree program covering land management and urban planning, including a component that mandates professional training and experience. As part of this, SURP provided the opportunity for 25 students to support the training and community mapping process. Each of the institutions had a specific role in the organisation of community mapping: from the provision of equipment to the implementation of the mapping forming a community of practice. Notability however, this community of practice does not wholly encompass the community that will do the mapping, nor does it reflect the process of preparation undertaken prior to the commencement of the community mapping, with the community of Tandale. This tension will be discussed in section 5.4.3.8.

#### 5.4.2.1 Mapping Preparation

Three days prior to the mapping, on the 4th of August 2011, organisers from GroundTruth and the World Bank met at the World Bank office in Dar es Salaam, to discuss the impending project and to evaluate the tools that were to be used for the mapping. These tools are described in Annex 3 and shown in Figure 5.1.

The tools were not sourced locally and were acquired and shipped from the USA by a member of the World Bank. It later transpired that this equipment was procured by Twaweza, shipped to the World Bank, then carried by their staff. Upon unpacking the tools, there was the expression of relief, that the equipment had "made it" from Washington, through to Addis Ababa, finally Dar es Salaam. This is mentioned as it the following implications:

1. There is little to no perceived local capacity for tools such as GPS, deemed necessary by the organisers - potentially an ethnocentric viewpoint;
2. The equipment was procured via a convoluted and complicated route. Upon further investigation, this was found to be due to regulations on the procurement of equipment

[1] The WEO

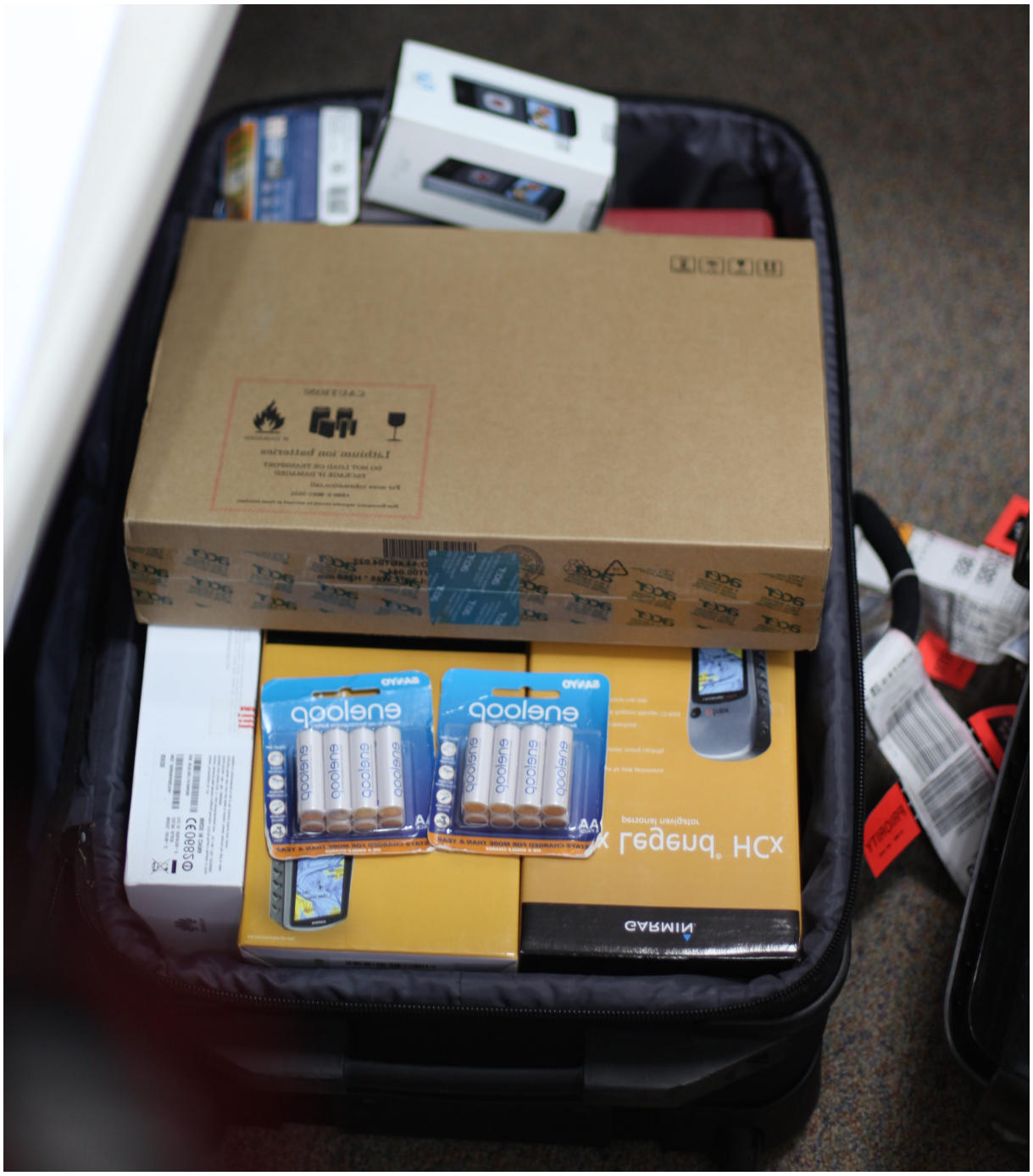


Figure 5.1: Equipment and Tools

and surveys, by one of the organisers, namely the World Bank. This provides a constraint on their capability, necessitating the building of consortia when equipment is needed and a potential constraint for full citizen control.

*This demonstrates a normative approach by the organisers.* The equipment was sourced due to the experiences and past knowledge of the organisers, with no respect to the local environment's technological capacity.

A preparatory workshop with 25 students from SURP was held, representing OSM. The intention of the organisers was to leverage the students' technical abilities and geographic skills to bridge an assumed capacity gap within the community members of Tandale. This assumption eventually was part proved, but not to the extent assumed by the organisers.

Subsequently, a search was conducted for a venue that would act as a base of operations, settling on the Ward Office. This was chosen due to its central location in the ward. The other option was a hotel, but this was deemed inappropriate due to the vibrancy of the environment. In basing the mapping in the Ward Office this provided community legitimacy to the project to some, but disenfranchised others in the community. This was not a factor known by the organisers at the time of selection - it was deemed potentially unsuitable as a location due to the lack of backup power and perceived small space. In the process of mapping, when residents queried the activities of the mappers in the field, the projects base of operation point that was the Ward Office, lent credence to this being an activity endorsed by the WEO. This in turn helped resolve challenges where Tandale community residents, unaware of the project questioned (at times aggressively) why mapping was being undertaken. Some of these fears were due to distrust in government and the implications of being surveyed such as increased taxation and risk of resettlement.

Finally, the current state of OSM was assessed. As mentioned in section 4.3.1 and shown in 4.6, the place tag indicating the position of Tandale was located in an adjoining ward. To reorientate Tandale in relation to Dar es Salaam, the ward office and the *Mtaa* boundaries were traced into OSM.

#### 5.4.2.2 Engaging Local Communities

It was rapidly recognised that the Tandale community subsequently needed to be engaged. This was done through a community forum, facilitated by the WEO of the DCC and CCI as *organisers*. The intention of the forum was to kick-off the community mapping, introduce community mapping and elicit specific areas that the community wished to focus on. Kikoyo (2011) describes the process of the forum as follows:

*"The forum was started off by a speech by Tandale Word Executive Officer. More*

*than 37 people [attended] including community members. Participants were happy to learn that they can be able to produce a map about their community and use to engage with the government and NGOs in the development and improvement of infrastructure. Currently Tandale and most of Dar es Salaam appears as blank spot on the Open Street Map platform."*

Figure 5.2: Community Forum

Figure 5.2 shows the forum in action. The format included a set of presentations from the organisers, such as the project manager, WEO and catalysers which shared experiences of community mapping from other projects. Specifically, these presentations involved OSM and the current lack of mapping within Tandale contrasting with maps of Kibera and Mathare in Nairobi, Kenya and the potential of this data to improve public service provision. Additionally, a tool for blogging and community journalism and a system for reporting community incidents was introduced.

The attendees were from the community of Tandale: local government officials from the *Kata* and *Mtaas*, 37 interested citizens and civil society group members combined with 25 SURP students. They had been brought together through word-of-mouth and advertising of the forum at ward and sub-ward offices. This inclusion of communities and local government in this fashion was novel, as Shkabatur (2014) discusses, comparing Ramani Tandale with Map Kibera. The relationship between the community and government will be discussed in later sub-sections and further on in this thesis on what this research has elicited in the proceeding

chapters.

A group discussion on the challenges faced by Tandale's residents followed the presentations. This led to the community *itself* identifying what was needed to be mapped. A brief discussion acknowledging the need for mapping roads and identifying amenities such as pharmacies and schools led into an in-depth discussion on the pressures of water access, sanitation and the impact of flooding. This discussion illuminated in part, the motivations of community members to participate in the community mapping.

Figure 5.3: A Water Seller (left) and Community Mapper (right)

Water and sanitation facility access in Tandale is not commonly within the dwellings of its residents, but is primarily through communal water tanks, latrines and Open Defecation Areas (ODA). Communal water tanks are mostly privately operated, with a small cost per jug - around 200 - 500/= Tanzanian Shillings ($0.07 - $0.20) per jug. A Tandale water seller, tank and jug is shown in Figure 5.3.

ODAs have severe public health implications. This not just an issue faced by Tandale's residents, but is a global issue challenge and a serious inhibitor to development: *"Not having access to sanitation means that people are forced to defecate in fields, ditches, buckets... and plastics bags "flying toilets" "* -Watkins (2006). As such, finding a resolution to ODAs is key part of the UN's Sustainable Development Goals (UN (2012)). Specifically, SDG 6.2: *"By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special*

Figure 5.4: Open Defecation Area around the Kiboko Stream

*attention to the needs of women and girls and those in vulnerable situations"*. Figure 5.4 shows an ODA in Tandale. Along with the remnants of *"flying toilets"* there exists large evidence of poor solid waste management, another challenge identified by the community forum.

Through the forum post discussions on mapping, a desire for *storytelling* of the challenges faced by the community arose. This coalesced around the concept of residents of Tandale presenting citizen media to challenge external perceptions of their ward, which according to residents were mostly negative. This helped inform composition of the groups and definition of roles, undertaken by community mapping participants.

At the time, the community forum was considered a useful approach for bringing together the wider community, setting strategic goals of the project and allowing the challenges faced by residents to be translated into actions to be resolved by the mapping. Kikoyo (2011) summarises the conclusions of the community forum, namely:

- *"The map produced will help improve dialogue between community and development partners for infrastructure improvements;*
- *Through citizen mapping, the community will highlight its own issues as opposed to mainstream media which focuses on mostly the negatives;*
- *The use of map and community reporting will help stimulate adoption of local solution to problems faced by the communities;*

- *The community will acquire new skills in ICT helpful in mass circulation / distribution of information".*

Retrospectively, it is evident that this is an essential process for enfranchising community mapping within a community and acts as an enabler for participation due to the community setting the approach of mapping. Following Arnstein's participatory framework, signifies that a community forum can facilitate the transition away from *Non-Participation* up the ladder where citizens gain more of a voice and participatory impact.

#### 5.4.2.3 Building Mtaa Teams

The first day of mapping on the 11th of August was challenging due to factors beyond the control of the project, namely power supply in the Ward Office. However, this presented an opportunity to form teams. These teams were in part self organising with the community members mapping their own *Mtaas* (Tumbo, Sokoni, Mharitani, Pakatcha, Mtogole and Mkunduge) and effectively choosing students to join their *Mtaa's* team.

Figure 5.5: Mapping Team for Sokoni Mtaa

Figure 5.5 shows the team for the *Mtaa* of Sokoni. During the mapping it was observed that each team member started to focus on a specific task, transitioning from students and community members to working as a group around their *Mtaa*. The roles that were organically

emerging were identified as: *organiser*, *catalyser*, *mapper*, *tracer*, *editor*, *storyteller*:

- **Organisers** were participants who supported the organisation and planning of Ramani Tandale, prior, during and after the community mapping campaign from an institutional standpoint;
- **Catalysers** helped catalyse the mapping, taking on further responsibility as their skills with mapping grew;
- **Mappers** undertook field surveys, using various mapping tools;
- **Tracers** tracers traced buildings and other natural features like rivers submitting them to the OSM database. They worked in conjunction with surveyors and editors to add context to the tracings. Generally, there was one satellite image tracer per group;
- **Editors** organised information from the surveyors and using GPS Babel to import data from a GPS receiver. This data was then uploaded into JOSM[2], adding data like road name or type. At regular intervals, this information as a new "changeset" is uploaded to the OSM database[3]. For each team there were generally two editors, one from the technically literate student group, the other a community member with knowledge of that specific area;
- **Storytellers** engaged with the community-at-large and provided a reflection and reporting of current events through the blogs and Ushahidi; communicating the issues faced by the community of Tandale. Photos were posted to a Flickr account or blogged on WordPress.

The function and relationship between these roles will be discussed in the subsequent section, examining the mapping process in action.

### 5.4.3 Implementation: Mapping Tandale

The mapping was sub-divided around the Mtaa groups. The formation of these groups consisted of around six to seven participants in each group, roughly an equal split between students and community members. Upon the formation of these groups the common question was *"where do we start?"*. The resolution was to *map with your feet*: the community members of the *Mtaa* took the students on a tour of it, showing amenities like pharmacies, water tanks and general stores. Each group picked up a GPS receiver, under the custodianship of a community member, then walked to their homes, also discussed by Parker (2012). This resolved the question on where to start mapping and throughout provided *Mtaa* groups with a method of identifying areas to map next: observe previous progression on OSM, identify unmapped area, go to unmapped area, and map it, translate the field data into OSM data through edit-

[2]JOSM, the acronym for "Java OpenStreetMap" was the main tool for editing and creating the geographic data of OSM at the time of mapping.

[3]A changeset is the addition of just 'new' data, instead reuploading the entire database.

ing, provide attribution for the feature, contribute to the OSM database, repeat the process. The process of exploration mirrors the concept of Naïve Geography (Egenhofer and Mark (1995)), in this manner the concept of place was shared between community mappers. The relationship between these situations is diagrammatically represented in Figure 5.6.

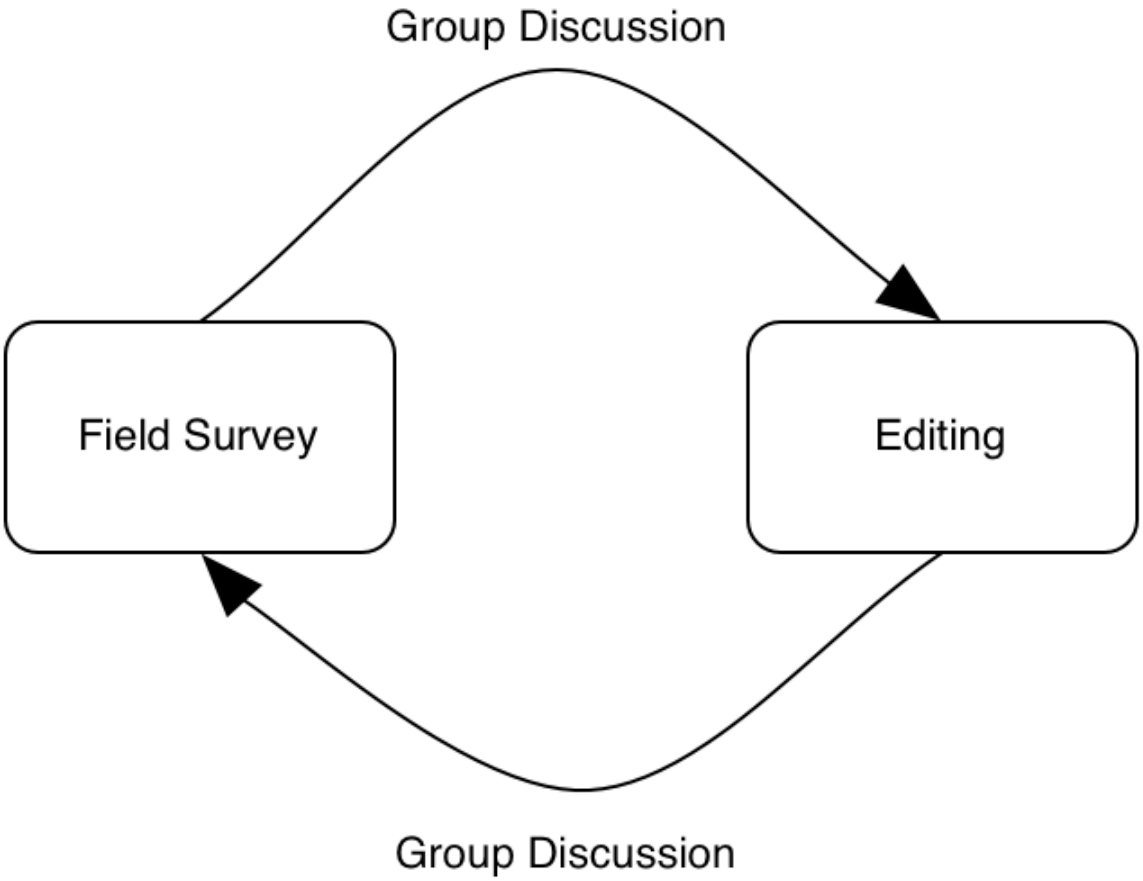


Figure 5.6: Map Data Collection Process

#### 5.4.3.1 The First Few Days: Building Technical Capacity and Data Sensitisation

Subsequent days started with a small community presentation on progress in their *Mtaa* and their mapping objectives for the day. The first time on returning to the Ward Office, each *Mtaa* team had tracks from a GPS receiver. The catalysers, namely instructors from Map Kibera provided a demonstration on how to download data from the GPS to the laptop and begin the editing and then uploading to OSM. All participants registered accounts for OSM, a necessary process to upload and contribute data to OSM, with some mappers needing to

create email accounts - a precursor to registering for an OSM account - but also illustrating the potential divide between the mappers, both community members and students. Once accounts were attained, the groups started to gain familiarity with the concept of the OSM's data model, tagging and editing software.

Ramm et al. (2011) provides an indepth dive into the OSM data model, demonstrating how the translation of physical geographic features, such as toilets or roads can be described in data. The model is composed of three basic elements, nodes, ways, and relations:

- *Nodes* define points in space;
- *Ways* a collection of nodes, that link and define linear features and area boundaries;
- *Relations* used to explain how other elements work together.

Within the context of Tandale, a *node* could be a toilet, a *way* a road and a *relation* being a bus route running over a collection of roads. The attributes of the geographic features are collected through *tags*.

Tagging is a core concept in contributing OSM and VGI data: it is how objects in the real world are translated into an ontology that organises and categorises features. Subsequently, these data features can be rendered, creating the map. Mooney et al. (2011) discusses the nature of tagging - *"OSM does maintain a community agreed list of tags that users can choose from...However, contributors are free to add their own additional tags to annotate spatial features"*. For the majority of features, these have a defined tag already, and as such it was the case that the mappers needed to adhere to the existing method of tagging. For example, to tag a toilet, the mapper would create a node, using a software editing tool. Then using the interface of the tool, declare "**amenity = toilet**". The opportunity exists to provide supplemental information, such as the type of toilet, or a road classification. A defined ontology is maintained by OSM in a wiki, but this is a guiding, not prescriptive framework. If the mapper chooses, they can create their own tagging schema/ontology, based on their own needs and requirements. The implications are to the core of designing a formative system of community mapping and is discussed later.

OSM has an ecosystem of software tools that allow for data editing and uploading to the OSM database. In the process of community mapping, the mappers had differing options for tools to volunteer data: during the mapping there were two main editors, *Potlatch* and *JOSM* during the mapping. Both were used:

- Potlatch is an editor that works in the browser and requires a constant internet connection. This proved problematic due to the intermittent nature of the power supply and mobile data network, though it was more user friendly and easier to use for quick edits;
- JOSM (shown in Figure 5.7) is an editor that works as a standalone program, which requires an internet connection to download data of the area of interest, subsequently allowing editing to take place offline. It requires an internet connection to upload again.

Figure 5.7: JOSM Editing of Pakatcha Mtaa

In comparison with Potlatch, it was considered less user friendly.

Over the course of Ramani Tandale, JOSM emerged as the editor of choice, due to its ability to incorporate a tagging schema and work in an environment of intermittent connectivity. The editing process was a social activity. Due to constraints of available computers (one per *Mtaa*) one group member took control of the computer, relying heavily on group discussion, (hence its inclusion in Figure 5.6) to direct the creation of geographic features. In part, this acted as a quality assurance/control measure as the majority of geographic features were discussed with regard to location and appropriate attribution; this process is demonstrated in Figure 5.7 and Figure 5.8.

Editing is one part of the mapping process, it is complemented by the *Field Survey*, as seen in 5.9.

Figure 5.9 and Figure 5.10 illustrate a common field collection process. Note the discussion between the mappers, around the GPS held by the central and right mappers, while the left mapper is note taking. This demonstrates the multitude of tools employed by the mappers during the mapping process. It was further evident that in creating the map, differing mappers had multiple strategies for collecting data: some data was collected through the tracing of satellite imagery during the editing process, some was collected during field surveys. This further indicates that community mapping already incorporate elements of formative systems, in that


Figure 5.8: Deep in Discussion: The Editing Process

Figure 5.9: Mixing Methods for Mapping a Street


Figure 5.10: GPS Receiver in action

no norm is described, but the option for mappers exists to utilise the tools and knowledge at their disposal, as opposed to be directed through one specific method of collection.

#### 5.4.3.2 The Progression of Mapping

The case study's mapping and editing was a continuous process, undertaken over three weeks. Figures 5.11, 5.12, 5.13, and 5.14 show the progress of Tandale, from the first week after the community forum to the final week of mapping. The progression shows the that differing *Mtaa* groups moved at different speeds, but ultimately reached the same level of coverage for certain geographic features, such as pathways and sanitation features.

#### 5.4.3.3 Examining Participant Roles: Mappers, Editors, Tracers

Initially, it was observed that mapping split into two main roles: that of the small set of planned *Organisers* and *Mappers*. Through observation and interviews with mapping participants, the roles in community mapping were identified, as discussed in section 5.4.2.3 previously. The role of the *organisers* has already been discussed, whose prior intention was that the combination of students and community members would collaborate in the community mapping task

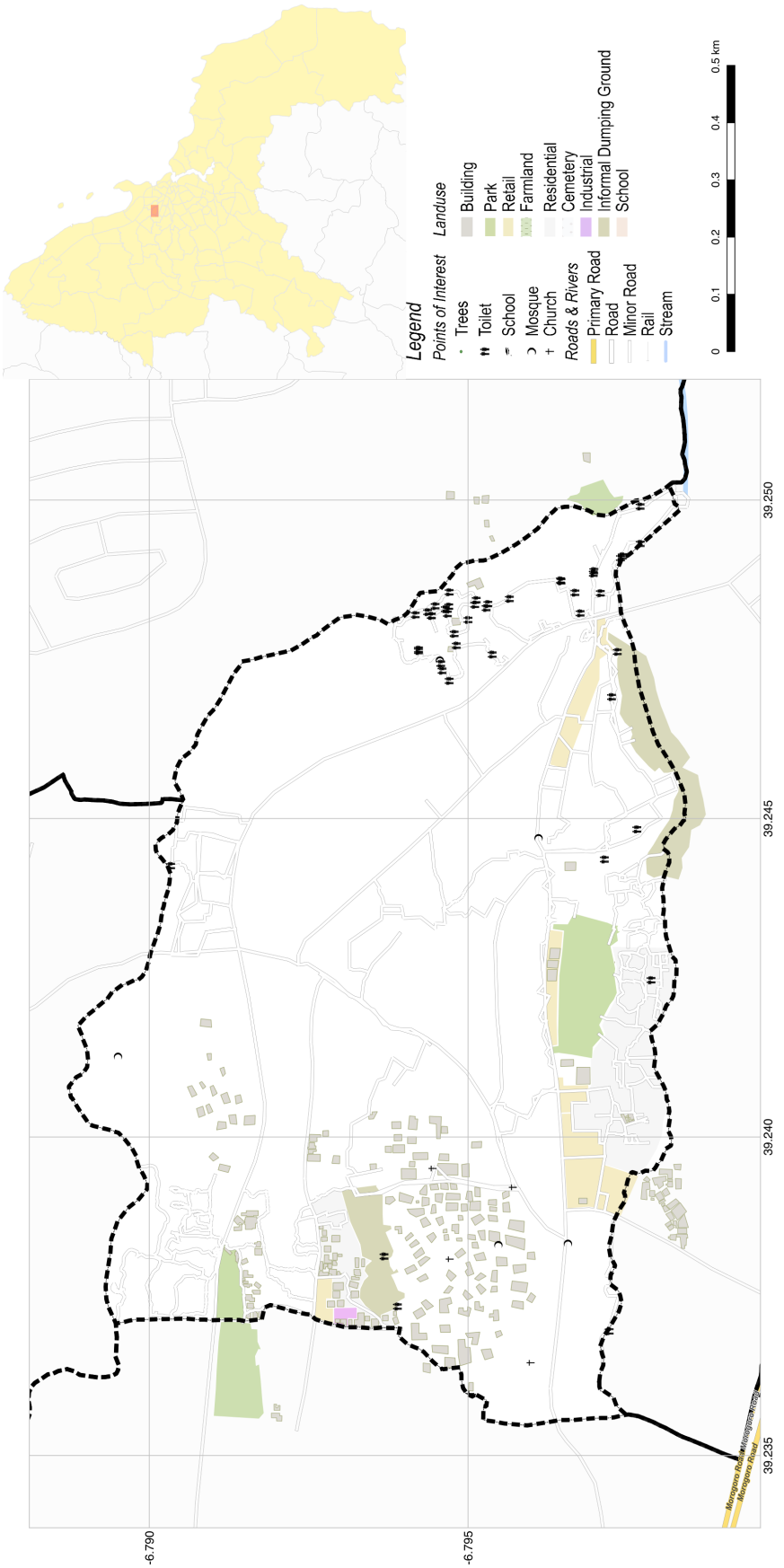


Figure 5.11: Ramani Tandale on the 15th of August

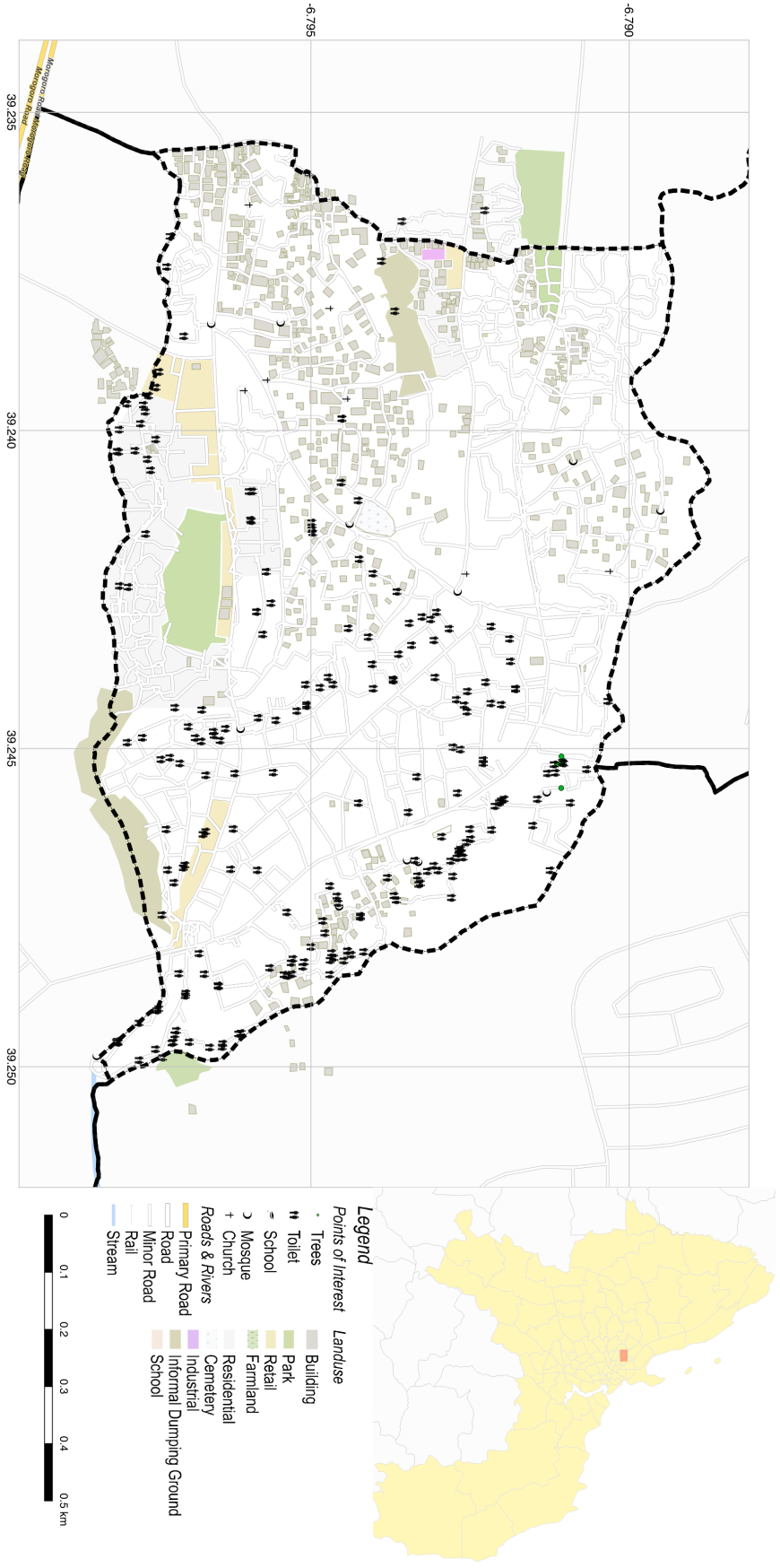


Figure 5.12: Ramani Tandale on the 19th of August

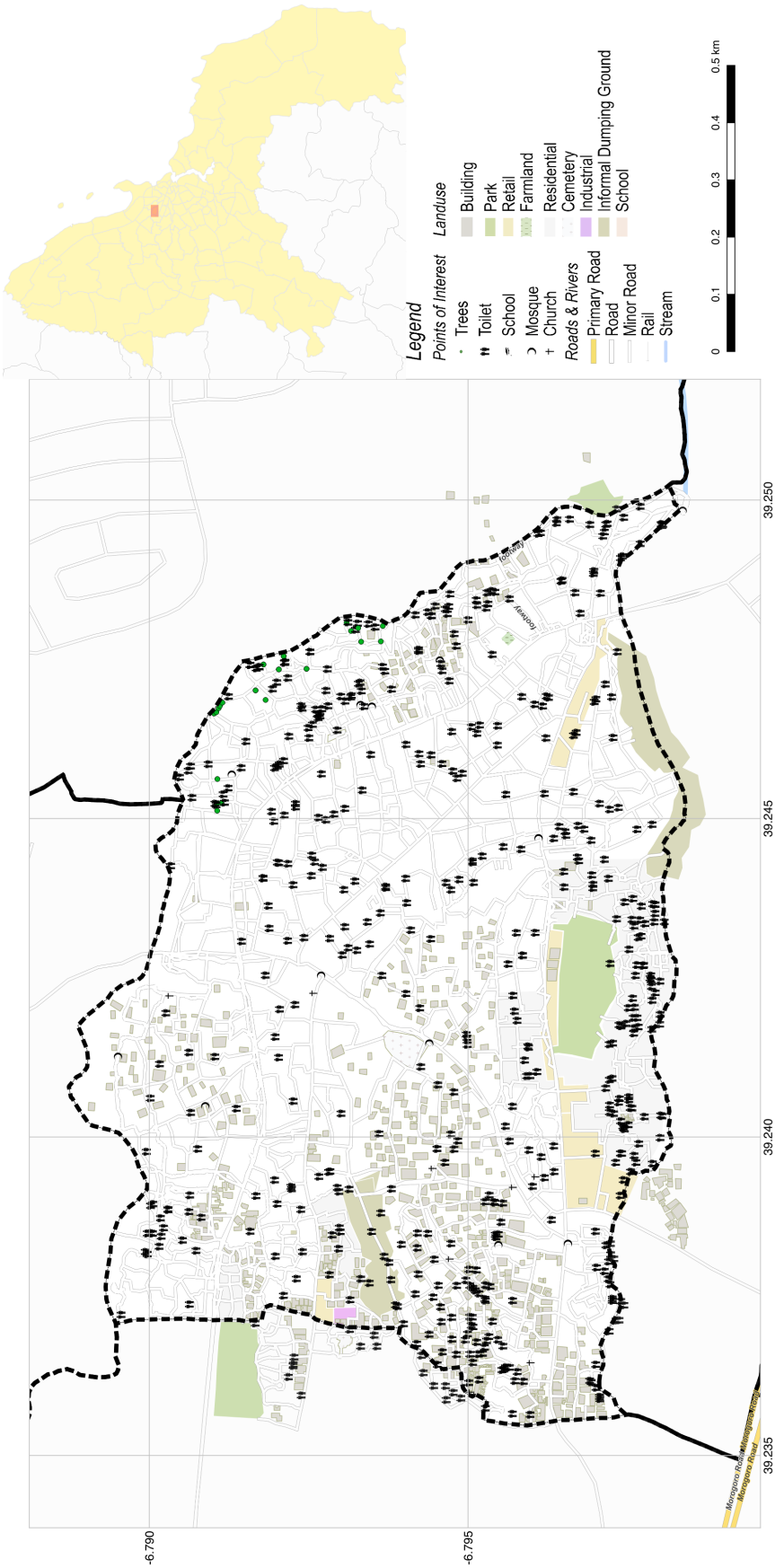


Figure 5.13: Ramani Tandale on the 24th of August

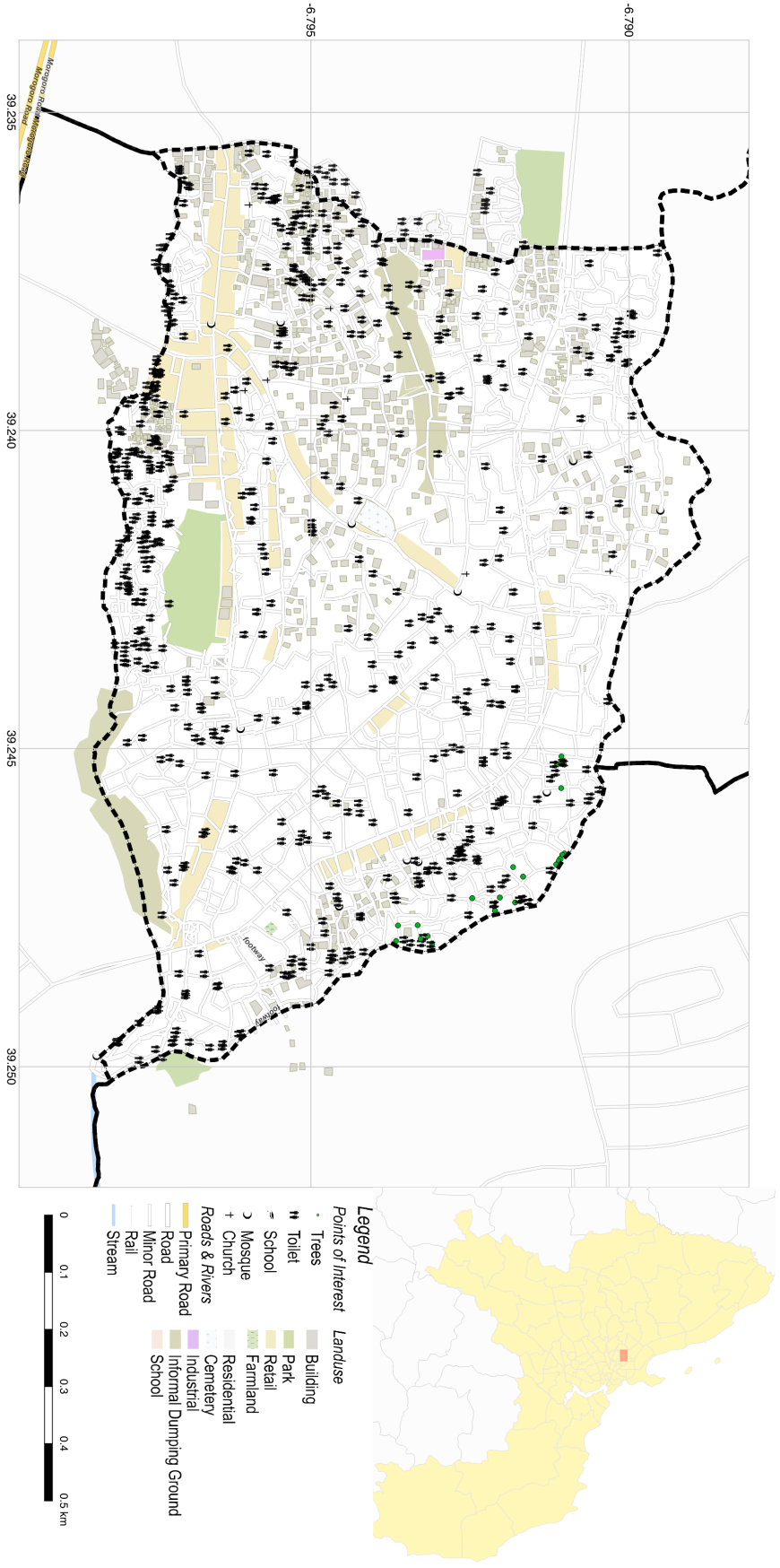


Figure 5.14: Tandale at the Completion of Mapping - 6th of September

as *mappers*. Though, this was the case at the start, further roles emerged due to the needs of the mapping process, namely *Catalysers*, *Tracers*, *Editors*, *Storytellers*.

Through the daily process of field surveys and editing, the groups organised their own roles where *Mappers* would exclusively map, passing their collected data, in the form of GPS tracks and notes to *Editors* in the ward office who would transform notes and data, uploading it to OSM. This separation of roles enabled mappers to go out and cover a larger area in a day, with two mapping and editing cycles, at the cost of a smaller team in the field, with 3-4 *mappers* (generally composed of 2 community members and 1 student) with 3-4 participants staying in the ward office. These groups formed organically.

In times where the editing was finished, but when a field team was out, the tracing of features from aerial imagery was undertaken: *"Alternating with others to trace buildings, I uploaded information, I learnt."* - (Mapper:5).

It was observed that *Tracers* contributed data to the map which would have been difficult to collect from a ground level with the tools used by the community mappers. A GPS and pen and paper was insufficient to collect feature data such as buildings, but it was observed that streets and pathways were traced through this manner. There is no data available for understanding the the balance of features collected through tracing and/or field survey (this is an area of future research and is discussed in Chapter 9). Additionally, as evidenced in Figure 5.13, the coverage of buildings is focused on *Pakatcha* and *Sokoni Mtaas*, whereas others, such as Tumbo had no building feature coverage, further indicating the choice that the community makes in prioritising feature collection.

The remaining two roles, of catalysers and storytellers will be discussed in the subsequent subsections.

#### 5.4.3.4 The Role of the Catalysts

Through observation as a participant and interviews with mapping facilitators in the organisation team, it became apparently that some participants did more than supervise the mapping, they acted as catalysts for the variety of roles:

> *"I was a facilitator for students and community in how to make a good map. I was a role model they see a youth like me it is a key role. Skills of collecting data, uploading data, how to communicate to the community a little bit of GIS knowledge, good mobilizer, facilitating, monitoring and evaluatingï£¡... On the second day I dedicated a community member to handle the GPS and I showed them how to collect the coordinates, the points. The member was willing to learn. I showed them once*

> *they rested, they did it accurately. After collecting the points, I showed him how to upload to the computer, until the last day we had the map."* (Catalyser:4)

Part of this approach was informed by prior community mapping activities undertaken by the mapping facilitators of the organisation team:

> *"My role was a trainer of trainees, training youth and community members in skills I acquired in Kenya. In Kenya I am a mapper, the skills I have are how to use the GPS for collecting data, tracks, and on software for the work to be uploaded."* (Catalyser:1)

These statements indicate existing knowledge of the process of community mapping, in terms of how to utilise tools to achieve a map, will affect the ultimate outcome of the community mapping process. These actions were to be expected, and necessitated as part of the role of mapping organiser. Yet the role of organising teams, setting directions, demonstrating GPS operation, collecting features though exclusively the domain of the organising team, eventually was replaced by a small cadre of catalysers, with roughly two catalysers from each team of 6-7 emerging organically, this was not an expected outcome.

> *"I teach the community how to use a GPS, how to create accounts, use "OSM", I discovered issues; poor water, sanitation, many issues."* (Mapper:5 - Community Member)

Over the course of the mapping, these catalysers gradually emerged and eventually took over the operational running of *mtaa* teams, to the point of coining the term *"catalysers"* themselves, upon discussing the nature of community participation:

> *"Catalysers and students are important to accelerate the project. People to share skills are needed; technological capacity doesn't exist within the community members."* (Mapper:5 - Community Member)

The emergence of these catalysers is positive development for the theory and praxis of *community mapping* in IDCs, and enhances the claim that this is truly community mapping as opposed to counter mapping, as discussed in the section 2.2. This will be discussed later, with relation to the significance of the differing modes of participation.

#### 5.4.3.5 Ephemerally Layering the Map: Raising the Community Voice

As evidenced by the community forums, community mapping has an equally important social dimension. These forums are held at the beginning and end of the technical component of the mapping implementation. The social component of community forums and broader engagement was enabled due to the detailed knowledge held by community members:

> *"They [the community] know the issues that affect them, i.e. where the hospitals are [informal and formal]. (Catalyst:1). "Waste points are very close to toilets. Water is a big problem; drainage channels are blocked... "Dawasco" the water authority has responsibility but they don't provide. They need a better system for monitoring."* (Mapper:6 - Student).

However, this knowledge of the geographic features in community was not universal, for example:

> *"Tandale community members don't always know where [are] the collection points for waste management."* (Mapper:6 - Student)

These statements are key in understanding the complex nature of the socio-technical system that community mapping operates within:

- **Some basic knowledge of the community is unknown:** For example, waste collection points. In contrast, the community mappers are cognisant of the relationship between poor water and sanitation facilities and the responsibility of the public water service, Dawasco, to provide such service, in which it fails to do so.
- **A desire to share information exists in response to this challenge of lack of knowledge and awareness of public services in Tandale:** *"The community is the key stakeholder, if you don't involve the community it will fail."* (Mapper:5 - Community Member) from this, there is a desire to a broadcast information to the local community, but also to a wider global community. While occurring in IACs, this is even more acute in IDCs.

#### 5.4.3.6 The Role of the Storytellers

These two challenges mentioned above were in part resolved through community media through *citizen journalism* and the use of a tool to *report* on public service delivery issues. These activities were coordinated by *Storytellers*, in each *mtaa* team. This took the map from a static artefact to a *"speaking map"* (Mapper:6 - Student). This has parallels with Hagen's intentions of providing "citizen journalism...[and] reporting by non-professionals on important local issues and news".

Citizen journalism was primarily undertaken through a blog:

> *"A blog can help report. The voice can be a voice for the community platform to highlight problems that occur. It is a community voice as the community themselves are reporting through the platform "speaking through the platform". No one person is listening, it is online - go there, you see it."* (Catalyst:4[4])

[4]This statement was from community member.

Blogs were augmented through videos and pictures of the entire mapping process, collected by the participants themselves demonstrated by Figure 5.15[5].


Figure 5.15: Community Media Creation

Complementary to citizen journalism, is citizen reporting. The reporting in Tandale utilised a platform called Ushahidi (Swahili for *testimony*) which Okolloh (2009) states *"harness[es] the benefits of crowdsourcing information... [to] facilitate the sharing of information in an environment where rumours and uncertainty were dominant"*. This is further expanded into how Ushahidi was used during the 2007/8 Kenyan post-election violence to provide information on incidents of violence due to censorship of media by the government and to create a memorial/archive of the events. The intention of the *Organisers* was to allow community members to identify public service gaps in their community through reports, Ushahidi enabled this:

> *"[The] map is interactive, they [the community] can come and tell us "giant pothole; the street lights haven't been put in; the trash hasn't been collected, needs feedback to supervise the implementation process as well as address the needs in a [sic] more timely and efficient manner."* (Organiser:2)

Figure 5.16 demonstrates the interface for Ushahidi, in Tandale, upon clicking one of the

[5] An example of the blog: tandale.ramanitanzania.org/blog

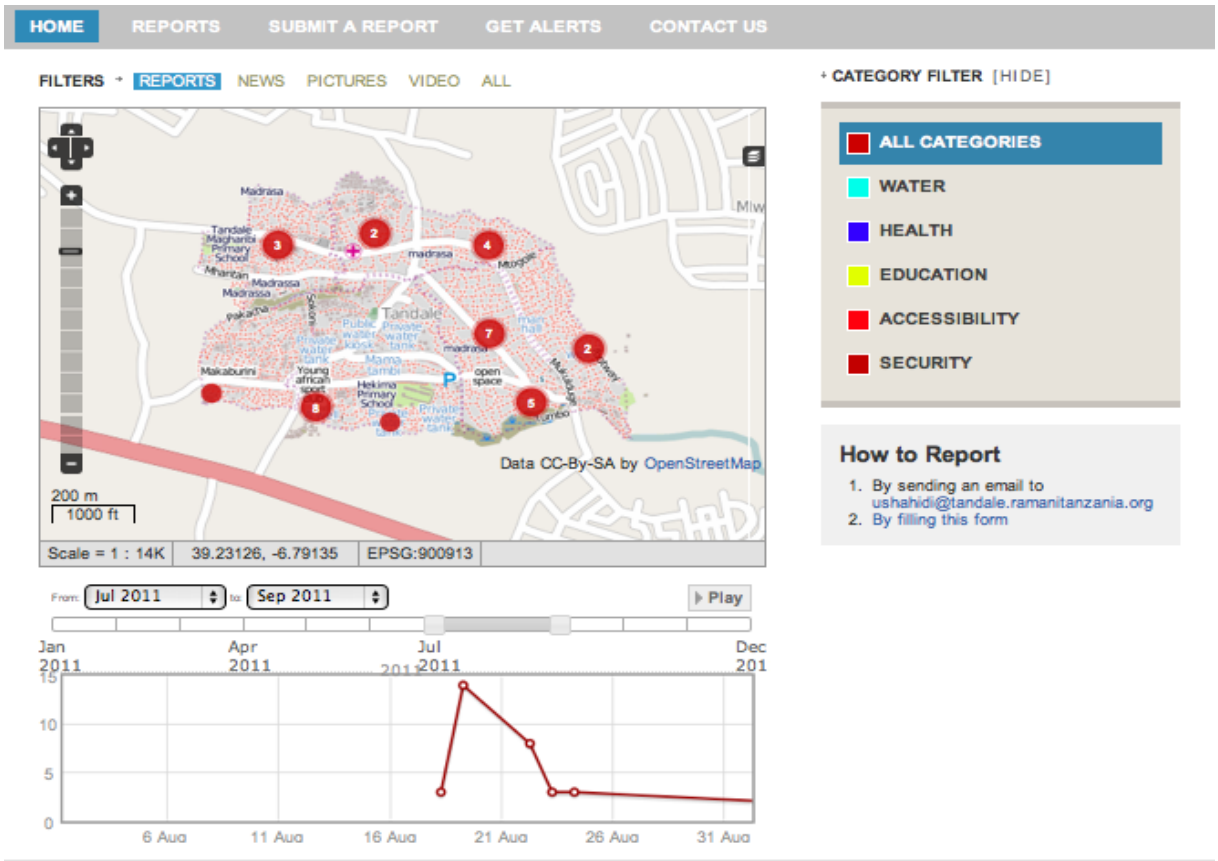


Figure 5.16: Ushahidi, Tandale

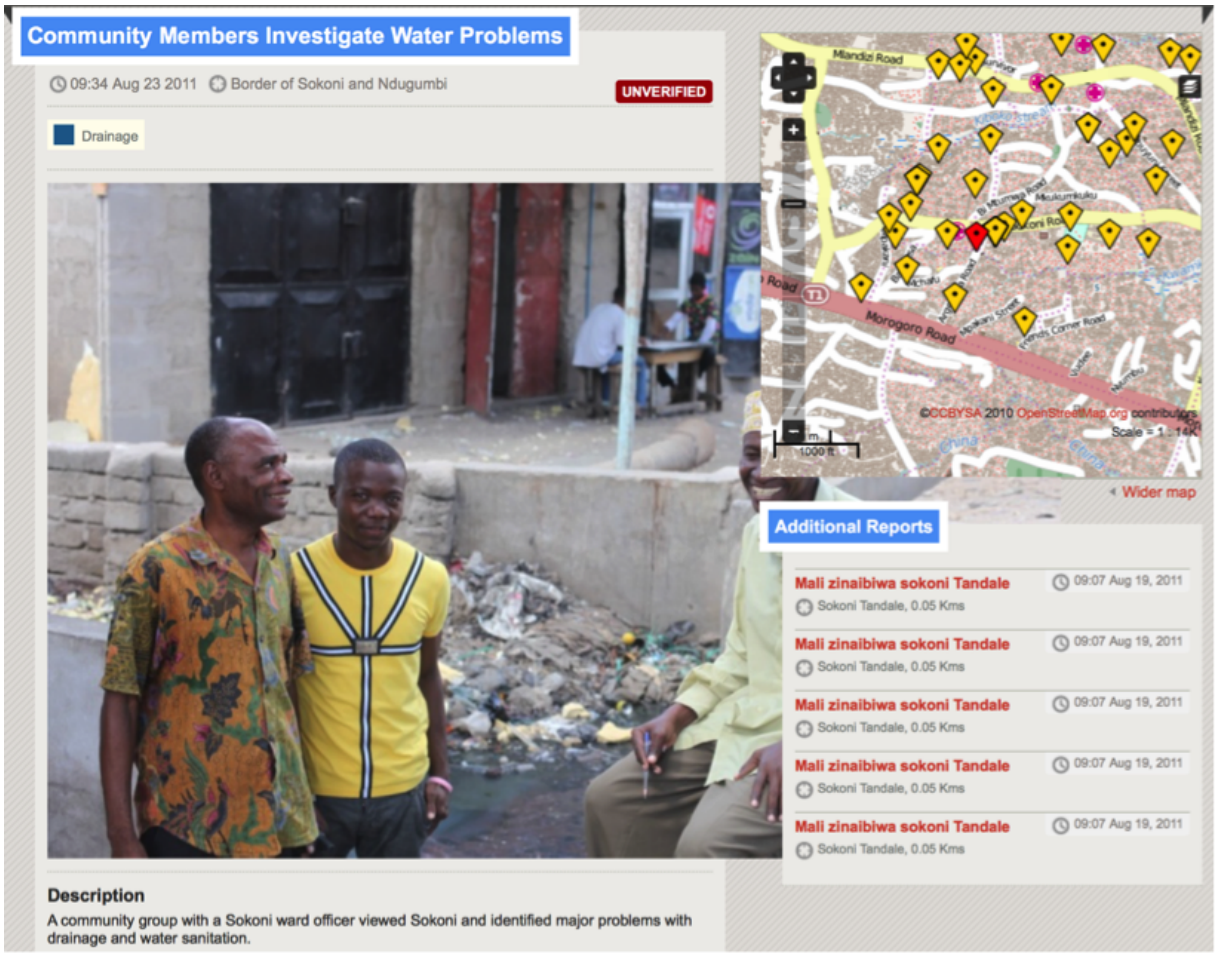


Figure 5.17: Community Report

report circles, the report for that location is shown as seen in Figure 5.17. This contains the time and date of the report, a photo, location and whether the report has been verified or not; this function was eventually carried out by *catalysers*. However, the use of the Ushahidi platform following the initial mapping campaign was limited and ultimately failed to engage community members. While the level of English of Tandale was relatively low, Swahili being the dominant language, the interface of Ushahidi was primarily in English. This contributed to its poor adoption and ultimate failure as a tool to report issues. There is also the concern of how such community reports would be actioned, this is discussed later. Both of the activities of citizen journalism and reporting were undertaken in the final week of the end of the project by the *Storytellers*. At this point, the map was complete - this concept will be discussed later. This left *mappers*, *editors* and *tracers* free to engage in quality assurance of data.

#### 5.4.3.7 Quality Assurance

Using the inbuilt logical consistency checks in JOSM, the *mappers*, *editors* and *tracers* identified topological, attribution and other errors within the data, as part of ensuring logical consistency and quality. This is a topic of further research and while important in terms of geographic information generally, is out-of-scope for this thesis. Nonetheless, this is an important concept that will be discussed in Chapter 7 in discussing the nature of authoritative VGI through community mapping and how community mapping can be considered as authoritative.

#### 5.4.3.8 Tensions and Challenges

Some *Mtaa* groups took longer to settle than others. This was due to tension between the students and community members.

> *"The problems in Tandale, the community wanted to do things without the students. When I was there, if I left a computer with a student, they would complain. They want to do things themselves, it was a positive thing, they wanted to lead. It took time for them to learn though."* (Catalyser:4)

Potentially this was due to a technology divide, where some participants were very fluent in technology, whereas others had little to no technical fluency. This also shows the nature of community. Recalling Arnstein's (1969) participatory framework, further up the ladder of citizen participation communities towards full control, the communities' enfranchise themselves. Demonstrably through these actions, the community of Tandale, through engaging with the community of students, had taken control of the project, this thesis holds the view that this is a necessary part of the community mapping process, reinforced by *"when I do this*

*again I must involve all stakeholders, for it has to be successful, working hand in hand. If I make a map and I go, no-one will use it. You make a map, involve the community and appoint it to those responsible for resolving those issues"* (Catalyser:4). This is shown within the Figures detailing the map's progression, where certain features being collected at the expense of others (hence lack of buildings in some *Mtaas*). This tension between the community mappers is a positive development, indicating this gap in skills is complemented with a gap in equipment. The primary tools used to collect the map data were a GPS, computer and pen and paper. In part this was due to limited funds. There are two potential responses to this:

- Utilisation of tools that were already in use within the community, avoiding the current necessity of equipment provision by external organisations; this would lead to true citizen control, as currently provision of equipment is at the behest of a supporting, although altruistic, organisation.
- Operationalising community mapping as a government run and sponsored activity.

The first potential response is complicated by the unique situation of an IDC: *"Annoying that equipment was destroyed, at local level"* (Mapper:7 - Student). The equipment used in community mapping was unfortunately destroyed in a flooding event across Dar es Salaam. This can only be mitigated through further planning and development of flood resilience programs. It is unknown if the maps were used in response to the flooding which occurred, with the flooding occurring after the initial round of interviews, but well before the second case study of this thesis. What is known, is that maps updated through Ramani Huria, the encompassing successor project to Ramani Tandale, have been used by the government and community members for investigating local issues such as solid waste management, planning the cleaning of drains and public health[6].

This second potential response was raised directly by one of the *Organisers*:

> *"Long way to go to operationalise community mapping, a lot of [government] bodies are not comfortable with how this tool can benefit them. A lot of barriers to the notion that this information can live in the public domain. So what does that look like when you further engage the public?"* (Organiser:3)

This highlights tensions at differing levels beyond the community mapping project. There are multiple factors causing these tensions, ranging from poor capacity, disagreement within and between government departments and perceived authoritativeness of the data, these factors are discussed in subsequent chapters.

Technically this was compounded with the languages of the software and tools not being localised for native Swahili speakers. This automatically marginalised certain mappers from

[6]This instances are detailed through an interview with government officials, the transcript of which is in the Annex

participating in certain processes. In combination with utilising tools local to Tandale, this further supports the notion towards a formative design of community mapping being needed which understands the constraints faced by community mappers, yet provides a design space for mapping.

### 5.4.4 Disseminating to Wider Communities of Practice

Upon the completion of the mapping process, forums were used to share the results of the community mapping. One forum involved the community of Tandale, the other involved the wider community of Dar es Salaam. This was in part due to the initial aims of the *Organisers*, *"The goal was to prepare geospatial information for it's implementation and to create a network for the public good"* (Organiser:3), leading to the to the following opinions from a community catalyst: *"For you to achieve your objective, when you start something, you need to share with the rest of the community"* (Catalyst:1) and *"The community is the key stakeholder, if you don't involve the community it will fail"* (Mapper:5 - Community Member). Theoretically, within the ladder of citizen participation, this demonstrates that the differing stakeholders, while having differing objectives can collaborate in creating the map, with control shifting away from the organisers and catalysts leading to the enfranchisement of community members themselves.

#### 5.4.4.1 Tandale Community Forum

The Tandale community forum was an open invitation event to the public in Tandale, supported by Catalysts and Organisers (the Ward Officer), attended by the community mappers and the general public. Maps were distributed, being created and printed by the organisers and distributed to attendees. This process demonstrates that the community was still not in full control of the project, and that map production (from skills in cartography to printer access) are constraints in IDCs, preventing full citizen control. These constraints and investigations into their resolution are beyond the scope of this thesis, but serve as a further indication the challenge faced by mapping IDCs as steps inhibiting the progression to full citizen control.

Discussion was led by community catalysts, with organisers being called upon, as opposed to the manner discussed in 5.4.4.2 and Figure 5.18 though as previously explained this was led by the organisers. The shift of responsibility for the organisation and execution of the community forum further demonstrates community ownership, but not full engagement. This is demonstrated by the challenge of reliance on outside *organisers* to provide tools to print.

Notwithstanding of this challenge moving towards full citizen control, a key part of this forum pivoted around community acceptance of the map. The community mappers, through

Figure 5.18: Community Members Discuss Map Features

the process described in 5.4.3 had already concluded the process of mapping to the point where the community mappers were satisfied that their work represented their community, the community forum offered an opportunity for the wider Tandale community to discuss and query the map, as evidenced by Figure 18. Additionally, during the community forum, the intention to continue mapping was expressed by the community mappers, yet this did not continue for reasons discussed later.

#### 5.4.4.2 Dar es Salaam Forum

After the community forum in Tandale, a wider forum was held by the organisers, attended by community mapping participants, but also a wider community including civil society, academia and differing levels of government, from the Dar es Salaam Mayor to WEOs, including Tandale:

> *"The ward and subward officers where there, the City Council and Mayor was there, as was the ward manager - a "Big Man" the expert of the ward of Tandale."* (Catalyser:4)

The combination of those directly involved in the community mapping and those indirectly involved, such as the Mayor (ultimately the WEO reports to the Mayor, though they were

not informed of the day-to-day progress of mapping). In expanding the community of participants, the forum focused less on the praxis of mapping, focusing on how such a map could potentially enable improvements in public service provision:

> *"Map it [then] they [the people] can come and tell us "giant pothole; the street lights haven't been put in; the trash hasn't been collected, needs feedback to supervise the implementation process as well as address the needs in a [sic] more timely and efficient manner'."* (Organiser:2)


Figure 5.19: Community Mapping Catalysers

Figure 5.19[7] and Figure 5.20[8] demonstrate the depth of participation of this this forum. Community members of Tandale attended, alongside the Mayor of Dar es Salaam, the Director General of the Tanzanian Commission of Science and Technology (COSTECH), an agency under the Government of Tanzania's Ministry of Science, Communication and Technology alongside project *Organisers*, such as the Dean of SURP from Ardhi University, the World Bank, Twaweza. Alongside these community mapping stakeholders', others attended from across academia and civil society.

[7]Left to Right: Edward Anderson, ICT Specialist, World Bank, the author, Lucy Fondo and Hassan Gazo - both of Map Kibera Trust.

[8]Left to Right: Mayor Jerry Silaa - The City of Dar es Salaam, Dr. Hassan Mshinda - Director General, Commission of Science and Technology, Prof John Lupala - Dean of the School of Urban and Regional Planning, Ardhi University, Barjor Mehta - Senior Urban Specialist, World Bank.

Figure 5.20: Community Mapping Organisers

A different community was engaged through this forum, as opposed to the hyper-local Tandale community as examined in 5.4.4.1, participation consisting of decision makers at a city and global level. Nonetheless, the theme of the agency of communities to conduct mapping was explored by the Mayor of Dar es Salaam. Goldstein (2011) quoting Mayor Jerry Silaa: *"The most important thing is that we involve the community in solving their own problems"* in discussing the map and its potential use. The utility of the map was further reinforced by the Director General of COSTECH, Dr Hassan Mshinda commenting on the potential for the mapping to improve public service delivery and city planning leading data driven policy decisions through *"linkages between industry and municipalities [that] can help a new generation of policy makers use evidence to implement policies to improve people's lives"*. As the Sub-Ward Officer discussed in Chapter 4 decisions at a local level are not made with maps, at the macro level of the city, this is also demonstrated here through this need.

The combination of this forum and the local Tandale forum demonstrate the differing communities ultimately engaged by community mapping: the local Tandale community, utilising community mapping in their neighbourhood to the broader community at city and national level. The combination of these communities is examined in the discussion, specifically with respect to prior theoretical statements of counter mapping, further supporting the argument of this thesis in defining community mapping in IDCs.

### 5.4.5 Ramani Tandale Discussion

The results of the case study in part answer the aim of this chapter/Research Objective 2, namely, **"Examine the praxis and characteristics of community mapping in IDCs"**. This will now be discussed, with respect to how this relates to the broader field of VGI, introducing other instances of community mapping globally, and how Ramani Tandale provided another spark for a global movement.

### 5.4.6 Future of Ramani Tandale

At the concluding community forum of Ramani Tandale it was observed that the mapping during August and September 2011 were not end of the project, just the beginning of a much wider and deeper community engagement: *"The project should continue; the community knows the process. The community expects improvements to come"* (Catalyst:7). With reflection a year later only one component of the community mapping continued, that being the community blog. The continuation of community blogging is without financial incentive or direct involvement of the original organisers, indicative of full *citizen control*. This thesis advocates the view that the lack of continuation in mapping and reporting, while unfortunate, is indicative of the wider challenges faced by communities such as Tandale, and those in IDCs generally.

BBC (2011) discuss the flooding in Dar es Salaam over five days in December 2011. These floods killed *"at least 20 people"*, displacing over 5,000 city residents. During this period Tandale was completely inundated with water leading to a complete loss of equipment: laptops, GPS and cameras were destroyed, preventing community members from contributing further in terms of the map. This had a challenging effect on Figure 4.5 demonstrates the after effect of the flood on what remains of a resident's bedroom.

Considering the flooding efforts to support mapping following this event were hindered. Storytelling through the community did however continue. Due to the pilot nature of Ramani Tandale, the maps themselves were not used during the floods, indicative of the challenges of accepting innovations such as Ramani Tandale within the governance structures that respond to such crises. Subsequently, Ramani Huria, as the project which expands Ramani Tandale has been used to map cholera events, see Appendix A.3. This is indicative of greater expansion of participation from local government officials and is illustrative of the fragmentation faced between government institutions in terms of coordinating actions.

From this perspective, the mapping can only go so far in supporting communities that conduct the mapping. A greater involvement of those that govern and support communities like

Tandale's needed to use data to resolve the challenges of the community. In describing the challenge of access to information: *"in unplanned areas they [the citizens] know what their problems are, but they lack the voice and quantitative message to get that message out"* (Organiser:2). This frames discussion on public service delivery as an access to information challenge, through community mapping, such data now exists. However, the data is not an end in itself, it is an enabler for improved skills among community members and improved governmental institutions and decision making, leading towards improved public service delivery - this will not happen overnight, even with a map. In terms of skills building for community members, as evidenced in 2 there is little formal research on how participant roles evolve and if this divergence is unique to IDCs. Parker (2012) discusses the interaction between the contributors of VGI and software developers, but this is limiting in that it occurs in an IAC and does not explore participant roles in depth, specifically with regard to *catalysers* and *storytellers*.

For Tandale and Dar es Salaam, the community mapping was well received at all levels of the community, from residents to government, as demonstrated in subsections 5.4.2.2 and 5.4.4.2. Notwithstanding the constraint of flooding, from the initial pilot of Ramani Tandale, COSTECH and World Bank as originating organisers of the project started to build the next iteration, Ramani Huria: Dar es Salaam (Swahili for "Open Mapping: Dar es Salaam"). This will be discussed in depth in Chapter 7. Ultimately, Ramani Tandale demonstrated that communities can collect data, leading to the creation maps that are representative of informal, unplanned communities, this institutionalised community mapping as a tool that can be used to make maps in IDCs.

### 5.4.7 Quality of Community Mapping Data: Designing for Good Quality

Community mapping inherently has quality assurance built in, as each feature is discussed by numerous community mappers leading to **community led decision making**, discussed in section 5.4.3.1. As such, the examination of geospatial quality analysis is inherently different in IDCs.

Haklay's (Haklay (2013b)) agenda discussed this challenge in the previous subsection, combined with the complexities of collecting VGI data through community mapping, *how can tools, objects and systems be designed that support communities in mapping their neighbourhood that inherently produce quality data?* As evidenced in section 5.4.3.1, relatively simple tasks that are taken for granted in IACs such as access to email accounts and internet access are severe inhibiting constraints to community mapping in IDCs. Consequently, this requires a thorough understanding of the design space of community mapping in IDCs, where the tools are either designed specifically for the environment or at localised for use. This should take into con-

sideration the skills and knowledge of local community members, as evidenced in subsection 5.4.3.8. As such CWA of community mapping is described in the subsequent chapter. This investigates a formative design for community mapping. The CWA then demonstrates how such a design can be used to provide maps that can aid in improving public service provision and epidemiology in IDCs, among other potential uses.

A thorough quality analysis of data from community mapping is out of the scope of this thesis, but is clearly the next step forward and is an area of future research, and is discussed in Chapter 8.

### 5.4.8 Towards a Socio-Technical System

Chapter 3 introduced CWA as a method for exploring complex socio-technical systems and their configuration. It does this by examining the boundaries and constraints of activities and tools used by participants in the work domain. This leads to a formative understanding of how new tools could be developed to respectfully exist in socio-technical systems. Vicente (1999) describes this through *formative systems*. Differing from *normative* systems which prescribe what the system *should* do, rather than what it *could* do. For example, a normative approach to community mapping potentially necessitates that all water points should be collected by GPS receivers. This would negate collection by pens and paper, an equally suitable method of collection. Potentially, a community mapping participant is constrained by their own technological ability or the fact that their equipment was destroyed in a flood, regardless of the constraint if they chose to participate they should have the ability to do so. This is important, as the roles in community mapping, evidenced in subsection 5.4.3.3 emerge over time, as opposed to being constrained.

Intertwining with the agenda of Haklay (2013b), the pace of technology and expansion of community mapping projects globally presents interesting opportunities and potential futures. Technology is changing constantly, for example UAVs could provide high quality aerial imagery, cloud free with both good temporal and image resolution. Mobile phone penetration across IDCs revolutionised banking sectors, through the provision of mobile money services - GSMA[9] (Muthiora (2015)), smart phone with GPS penetration is also climbing rapidly. This has the potential to change the environment of how community mapping participants engage with tools to create maps, for instance by removing constraints of access to tools like GPS receivers. As such, a need for a *formative* system for the work domain of community mapping is necessitated. This is achieved through a CWA, presented in the next chapter.

[9]The GSM Association - the Industry body for mobile phone telecom operators.

### 5.4.9 Discussion Summary

Notably, at the time of this case study in 2011, community mapping projects in the Philippines, Indonesia, Mongolia and Nepal were not yet existing, with Kibera, Nairobi, Kenya and Port-au-Prince, Haiti being the examples under a loose definition of community mapping alongside examples by Gerlach (2015) and Chambers (2006). In terms of direct quality analysis Koukoletsos (2012) examined the Haitian dataset comparing two VGI datasets and an authoritative dataset from the UN Stabilisation Mission for Haiti. The outcomes of this were analogous to the findings of the investigation detailed in Chapter 4, finding that the authoritative dataset was of a lesser quality than the VGI data. This further supports trust in VGI data, collected by community mapping, but validates the assertion in Chapter 4 that "the IDC domain necessitates a different approach". The approach advocated by this thesis is to explore community mapping as a socio-technical work domain, through building a CWA.

## 5.5 Chapter Summary

This chapter presented a case study of community mapping in Tandale. This in part resolved the research question *"what is community mapping"*, further identifying the need to describe community mapping as a socio-technical work domain and eliciting requirements for a formative design. This is investigated in the next chapter, exploring a formative design space for tools for community mapping to be built.

# Chapter 6

# Community Mapping as a Socio-Technical System

## 6.1 Introduction

This chapter builds upon the previous investigation of community mapping and its conceptual framework presented in Chapter 5, using the Cognitive Work Analysis (CWA) method to describe community mapping as a socio-technical system. This grounds the CWA method in a VGI environment, where it will be used in the following chapter to examine how tools can be appropriately designed and deployed in IDCs. Where Chapter 5 took an exploratory approach to understanding and establishing community mapping in IDCs, this chapter investigates how community mapping can be understood as a socio-technical system. This Chapter draws heavily from the background of CWA detailed in Chapter 3.

To accomplish the examination of community mapping as a socio-technical system, a further study of community mapping was conducted. Potentially, it would be possible to base the construction of a CWA from the initial findings of Chapter 5, though opportunity existed to reinforce the findings of Chapter 5. Due to the complexity and challenging nature of IDCs, this opportunity was taken, this further supports the results discussed in this chapter as being *context-independent* Stanton and McIlroy (2012) and applicable to other environments in IDCs. The outcome of this presents a formative design space for community mapping. This answers Research Objective 3, **"Determine the constraints of the design space of community mapping in IDCs"**.

## 6.2 Method and Data Collection

Rasmussen et al. (1994b) initially presents the concise conceptual framework of CWA and this is expanded upon by Vicente (1999) offering a case study approach based on how CWA is utilised in real world systems, such as simulating thermal-hydraulic process systems but also aircraft carrier flight operations. Notably, as discussed in Chapter 3, this is a novel application of CWA, as it has not been applied to the work domain of community mapping previously.

The CWA is constructed using a similar mixed methods approach to the case study in Chapter 5, using semi-structured interviews and participant observation as discussed by Gold (1958) and Robson (2011).

In contrast to the case study in Chapter 5, which utilised observer as a participant, this case study was conducted with the view of constructing a CWA. To observe community mapping in as a natural, a state as possible, the *participant as an observer* method was chosen, in contrast with the previous study which utilised as a *observer as a participant*.

The main difference between these two methods is the role of the observer: In *observer as a participant* the researcher is directly involved, whereas in *participant as an observer* the researcher is passive, but as discussed by Gold (1958), the researcher is not entirely removed from the participation process. In both case studies the role of the author, using the roles identified in Chapter 5 was of an *organiser*, albeit in this case one who is primarily concerned with observation of the process. The contrast in methods, additionally supported the previous definition of participant roles in community mapping, while also allowing for a critical examination of how community mapping exists as a complex socio-technical system.

## 6.3 Community Mapping in Tandale: Redux

Section 7.3.3 introduced how Ramani Tandale institutionalised community mapping within the World Bank, with community mapping used as a tool in the Philippines, Indonesia, Mongolia, (Haklay et al. (2014)); Nepal (Haklay et al. (2014); Soden et al. (2014)); and Haiti (Soden et al. (2014)) for collecting map data.

Yet, the components of community mapping as a socio-technical system are not well understood; providing motivation for this case study. This serendipitously aligned with an opportunity to demonstrate community mapping to the Tanzanian Commission of Science and Technology (COSTECH) at their request to examine potential for using community mapping to identify flood prone areas. This was due to the lack of accessible data on flooding in Dar es Salaam and due to the situation of regular bi-annual flooding in the city.

### 6.3.1 Method

Similarly to the case study detailed in section 5.3 an extensive set of field notes, photos, and blogs were recorded by the author containing progression reports and videos of mapping in practice. These field notes of observations were augmented by semi-structured interviews with community mapping participants, undertaken directly after the end of this phase of mapping. In all, there were a total of 15 mapping participants, a smaller sample than the previous study, however, this is reflected by the smaller study area.

As with Chapter 5 case of Ramani Tandale, the process and sequencing of mapping is similar. As before, a group of organisers (World Bank, COSTECH) collaborated with knowledge institutions (University of Ardhi and COSTECH), local government (Dar es Salaam City Council), and community members from Tandale.

Interviews targeted the *catalyser* and *mappers* roles. This approach was taken to elicit as much information as possible regarding the process of mapping. Within these roles, there was also an equal number of students and community members being interviewed - this is noted within the text below and in A - this was to balance input and investigate the extent of community participation.

Through the choice of CWA as a method to understand community mapping as a socio-technical system, a requirement exists to understand community mapping as a Work Domain. One *catalyser* and eight *mappers* participated in the community mapping task. From this the *catalyser* and four *mappers* were subsequently interviewed, using the same coding as section 5.3. Findings are also compared with the previous case study.

This approach was combined with the requirement of identifying and decomposing high level concepts as a starting point to building a *context-independent* CWA of community mapping.

### 6.3.2 Results

The second community mapping project in Tandale, started on February 10th 2014, organised by the author under the auspices of working for the World Bank, supported by COSTECH, Dar es Salaam City Council, through a supportive Ward Executive Officer, University of Dar es Salaam through provision of four geography students and community members of Tandale.

The data available for Tandale did not significantly progress in the time between the two case studies. Potential reasons for this will be discussed in this section's synopsis. Due to constraints of time, only the Tandale *mtaa* of Pakatcha was mapped, a decision taken between the Ward Executive Officer (an *organiser*) and community mapping participants.

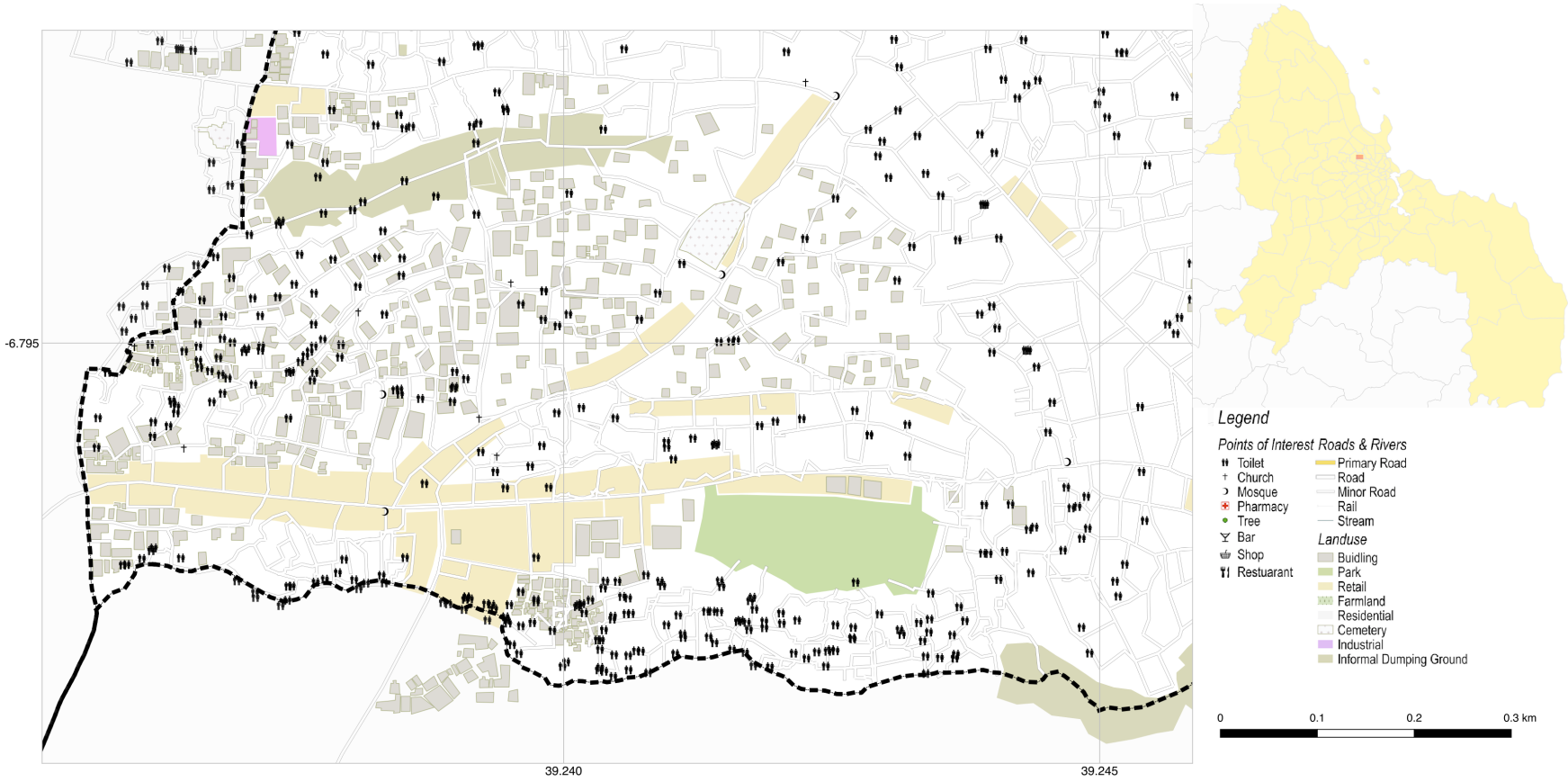


Figure 6.1: Pakatcha data extent prior to mapping

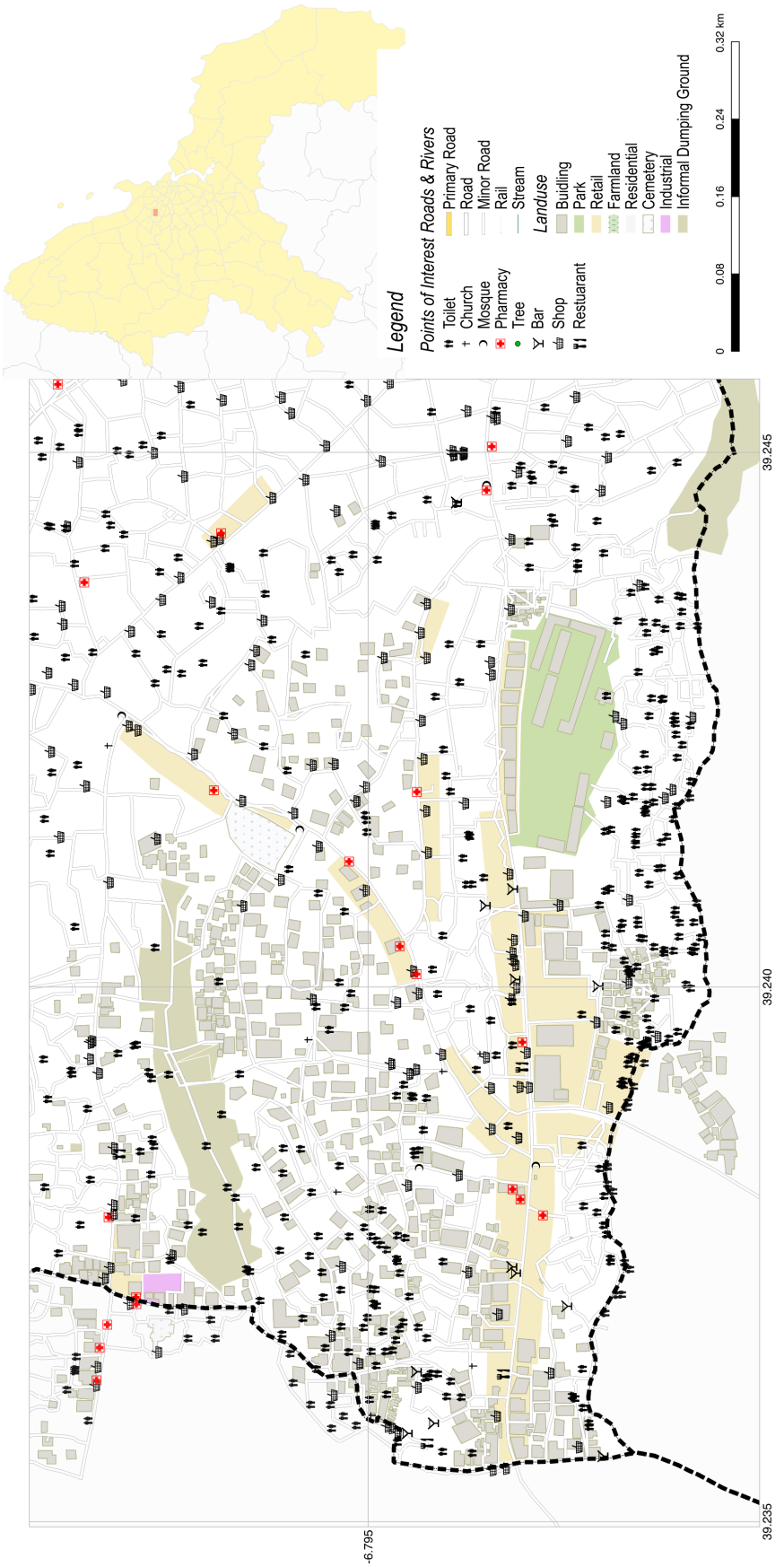


Figure 6.2: Pakatcha data post mapping

Figures 6.1 and 6.2 present the extent of the Pakatcha mtaa, one of six mtaas that comprise Tandale, before and after the mapping respectively. Figure 6.2 demonstrates enhanced drainage networks collected as part of the community mapping process. This was a direct requirement of the community, elicited through a community forum. On reflection this led to conflicting views by the participants on how the community views flooding and its cause:

> *"At that community or for Tandale, first of all, it seems that the people of Tandale, maybe they are unaware of the problem which are facing them. Maybe they used to dump all the waste or throw their solid waste in the drains without maybe care."*
> Mapper:11 - Student

Contrasting with:

> *"I have tried to ask a few of the people why are they doing this and what are the consequence of dumping this solid waste within the drainage channels, so that during the rainy season they are having the problem of blockage of this channel. They have broken this water channels to be flowing out, then they cause back follow of water, then it causes floods during. Let's say what have been done to reduce this problem of dumping this solid waste within those natural drainage systems. You can say that there is not much pain from the local leaders, but the aims of the community, they have make the task of removing this solid waste along this major draining channels."*
> Mapper:10 - Community

This further supports the notion and need for communities to define their own objectives and assume *citizen control* of said activities. The previous points of view, regardless of their difference on how much the wider community is aware of the consequences of their actions in discarding solid waste, ultimately leading to blocked drainage and subsequent flooding, stands apart from the initial cause. This is due to a lack of accessible solid waste disposal points in Tandale - a provision of public services issue. This demonstrates a need to understand the *purpose, priorities and values* of community mapping; core concepts that need to be understood prior to constructing a CWA. As such, this case study differs from the previous case study in that themes relevant to socio-technical systems will be elicited from observations and interviews, alongside a discussion of the mapping process. This case study illuminates the *formative* nature of community mapping, contrasting with the descriptive approach of the previous chapter.

### 6.3.3 Establishing System Purposes

This thesis argues and ultimately demonstrates that community mapping is a useful approach to respond to the challenge of lack of geographic information in IDCs. In Tanzania this was directed due to institutions such as the World Bank and the Government of Tanzania, as discussed in section 5.4.1. These institutions demonstrate thinking at a top-level, whereas on the

ground exists community members, such as those in Tandale. Stated goals and intentions of both groups can be encapsulated in terms of *Development and Governance*. *Organisers* and community members stated this desire, Organiser:2 stating that the reason for participation was for *"gathering [geospatial] information and strengthening capacity in local government for improving capacity for infrastructure and planning... How do you generate [geospatial] information relevant to communities?"* this aligns with Mapper:9 (Student) who wished for *"principles and awareness on how to represent the information, and on the view of the community itself, both on how they pursue their problems that they're facing, or on how or what they need to making a solution to their problems, for transferring those ideas into mapping consideration"*.

As such, the following sections elicit the socio-technical concepts of community mapping and expand on how different roles continue to participate.

### 6.3.4 Establishing System Values and Priorities

Concepts such as *Provision of Services* and *Urban Planning* can be contrasted with concepts of *Development and Governance* and *Provision of Geographic Information*. In that *Provision of Services* and *Urban Planning"* are **values** of the community mapping system, in that they enable the higher level **purposes** of *Provision of Services* and *Urban Planning*. The latter concept is presented by Mapper:8 (Student) in discussing the participation of community members in mapping with a *need to go one step further to involve the community [sic]and planning"*. These values are not just unique to Tandale and/or Dar es Salaam, but are applicable to other contexts as demonstrated by Sen et al. (2003).

Other values identified include *Quality*, as a critical component of data, *"First is the identification and creation of high quality geospatial data at the community level"* - Organiser:3. The relationship of these concepts, presents the beginnings of a means-ends hierarchy (Vicente (1999)). In this **Functional Purposes** such as *Development and Governance* and *Provision of Geographic Information* are the end, achieved through the means of *Provision of Services* and *Urban Planning*.

Equally, *Provision of Services* is an end achieved through means of *Allocation of Capital, Location Data, Demographics and Statistics*, among other functions. Notably, none of these functions are specific to community mapping, but are general concepts inherent to either the governance of a country or providing geographic information, linking back to the *end* **purposes** of community mapping.

#### 6.3.4.1 Establishing Processes and Physical Objects

Socio-technical systems, while having Purposes, Values, and Priorities, as discussed in the previous section, also have Processes and Objects. These have the same relationship together as described above, in that **Physical Objects** are the *means* to achieve the *ends* of a **Object Related Process**. For example, the combination of the objects of GPS receiver and Mobile Phone, as demonstrated in section Chapter 5 leads to Data Capture (ie. The creation of a map). However, if used differently, the same **Physical Objects** can be used for Communication.

Schaller (1997) holds Moore's Law in the technological zeitgeist as a rough guiding principle for the advancement of technology. In comparison with the previous case study, taking place in 2011, this study of 2014 marked a change in technology available, with mobile phones of the time more capable of data capture. In terms of mapping and presenting tools, the largest impact was not due to the advancement of technology (though the impact and availability of new datasets will be discussed later) but also removal of previous constraints, such as electricity, internet access, and printing equipment. The poor access to printing equipment especially had an impact as it prevented community mappers from using a newly developed tool called Field Papers in 2011.

Figure 6.3: Field Papers Mapping a Drain

Field papers are a web based tool, that can be used to print the current extent of maps in OSM, as shown in Figure 6.3. This enables *mappers* to sketch and note take, directly onto the maps. In 2014, this replaced the GPS as the primary tool for mappers to collect data, as this interview discussion with the author and Catalyst:12 indicates:

> Catalyst:12: *"With the field papers which shows the existing situation, it can be easy to update and sketch what you can see on the ground. Then use that to edit on JOSM before you upload in OpenStreetMap."* Author: *"How did that differ from the mapping you've done previous? Did you use field papers and sketch maps before?"* Catalyst:12 *"That differs because before we didn't use field papers we just used GPSs, we were depending only on GPSs whereby we were taking point then writing down the attribute of the point. Now, we have used field paper. We used GPS but it was purposely for tracking where we were moving, but doing the real mapping we were using field papers for sketching."*

This also changed the **role** of the *editors*, as mapping was done faster. Additionally, it was observed that the role of *editors* was not as distinct as in the previous case study: with *mappers* and *editors* being more homogeneous. The impact of participation of *editors* in the Field Survey is an area of future research, a hypothesis would be to propose that the involvement of *editors* in the field would lead to higher thematic and attribute quality, due to the role's continued engagement and presumed fluency with the attribute and tagging schema of OSM.

The addition of the Field Papers tool, did not change other aspects of the praxis of community mapping. Discussion between members of the community and *mappers* still took place regarding tagging and attribution during the field as evidenced by Figure 6.5.

The availability of new tools and enhanced functionality of physical objects such as mobile phones (as shown in Figure 6.6) enabled *mapping* to emerge from community mappers in a much more organic, less directed fashion, where they operated within the constraints of the environment and technology available.

Contrasting with the section 5.4.2.1 where technology was bought in from outside Tanzania, in this instance, technology utilised came from participants as noted by Mapper:11(student): *"We're collecting data using the GPS and also using our phones for taking pictures for the map of Tandale"*. This indicates a much more sustainable approach for community mapping. As indicated previously, flooding in Dar es Salaam post 2011 destroyed all equipment.

As such, community mappers, regardless of level of engagement, were unable to contribute, though continued to support community media. Community mapping will become sustainable if communities are able to leverage the tools they have available to use, as opposed to being dependent on others for the provision of tools.

Figure 6.4: Editing With Field Papers

#### 6.3.4.2 Synopsis

The previous sections identified some of the characteristics of the community mapping environment, from high level purposes to the physical objects that support community mapping. This provides further groundwork for the construction of the CWA in the later section 6.4 that presents community mapping as a socio-technical system.

Within this case, after the mapping had finished, interviews were conducted with participants and the outputs discussed with the community at-large, such as COSTECH, and detailed in Simba (2014).

### 6.3.5 Phases of Community Mapping

Section 5.4.3 presented a simplistic model of the phases of community mapping, specifically regarding the relationship between the Field Survey and Editing phases. Yet, as identified through interviews and observations, these are two situations in the larger system. These situations are:

Figure 6.5: Community Discussion

**Preparation** The situation where *organisers* prepare for community mapping, this could include the building of an alliance of organisations from civil society organisations to

Figure 6.6: Field Surveying with a Mobile Phone

academia, as evidenced in 5.4.2 or the preparation of equipment, as evidenced in section 5.4.2.1.

**Field Survey** Where *mappers* collect data. Examined in section 5.4.3.2;

**Editing** Where *Editors* collect data from Examined in sections 5.4.3.1 and 6.3.4.1;

**Quality Assurance** The process of data assessment as a during editing and in reflection, discussed in 5.4.3.7;

**Community Engagement** This could involve community forums to inform and elicit priorities for mapping, evidenced by section 5.4.2.2 or through community mediated communications through *storytellers* such as blogs as evidenced by section 5.4.3.6 or broader engagement with city or national officials as discussed in section 5.4.4.2;

**Post Mapping Phase** This could include further mapping, communications and is purely at the discretion of community members to exercise their own *citizen power*, as they traverse up the ladder of citizen participation.

A visual way to see the interaction of the situations is shown in Figure 6.7. The intersection of how these situations relate to the roles and the intersection of situations, functions and roles is presented later in section 6.4.3.5.

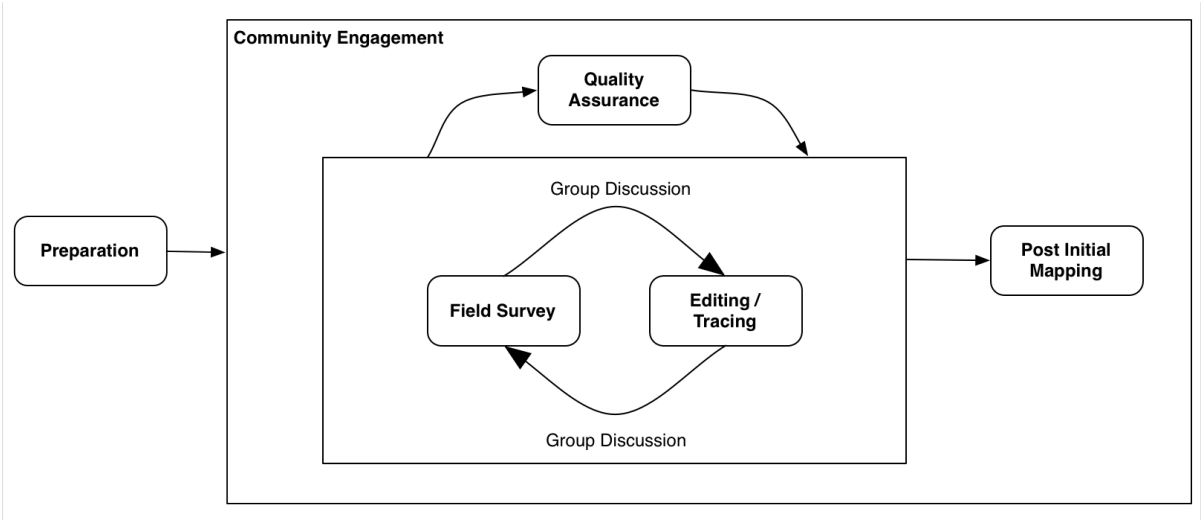


Figure 6.7: Phases of Community Mapping

### 6.3.6 Discussion

The results of this case study resolve the need for a descriptive understanding of community mapping, enabling the construction of a CWA. Combing with Chapter 5, the Research Objective 3 **"Determine the constraints of the design space of community mapping in IDCs"** is resolved. Examining two instances of community mapping, though in the same location offered the opportunity to compare and contrast factors to understand the concepts of community mapping.

As discussed in 6.3.4.1, this enabled an understanding of how the constraints of available technology and development of new tools, exemplified through the "Field Papers" tool, which was a preferred tool for *mappers*, supplanting a GPS receiver, the preferred tool of the first case study. Regardless of the usage of these tools, ultimately the result was the same - a community map was produced, based upon the community's concerns - here specifically drains, culverts and other features that could enable an understanding of flood prone areas - with the intention of making this data available to those that can act upon it. This notion of appropriate technology indicates how an understanding of motivations and constraints necessitate a need for a *formative* space for community mapping. This is achieved through constructing a CWA.

## 6.4 Cognitive Work Analysis of Community Mapping

This section presents a CWA of community mapping in IDCs. This does not describe specific community mapping events, but presents a design space of the community mapping work domain. The definition of concepts and their inter-relational connectivity used to build the

CWA is directly informed by the two case studies of community mapping, of sections 5.4 and 6.3.

### 6.4.1 Phase 1: Work Domain Analysis

McIlroy and Stanton (2011) define the work domain as *"the environment in which workers operate, [by] identifying the constraints that shape activity within the system"* (p360). This understanding is achieved by building an Abstraction Hierarchy (AH), which leads to an *Abstraction-Decomposition Space* (ADS). An AH describes the various abstracted levels of the system, at its highest level, it describes the system's functional purpose and at the lowest the physical objects of the system. An ADS represents the components of the system so that the system's physical constraints can be examined (Hajdukiewicz and Vicente (2004)). The Work Domain being analysed here is the work domain of community mapping.

#### 6.4.1.1 Abstraction Hierarchy

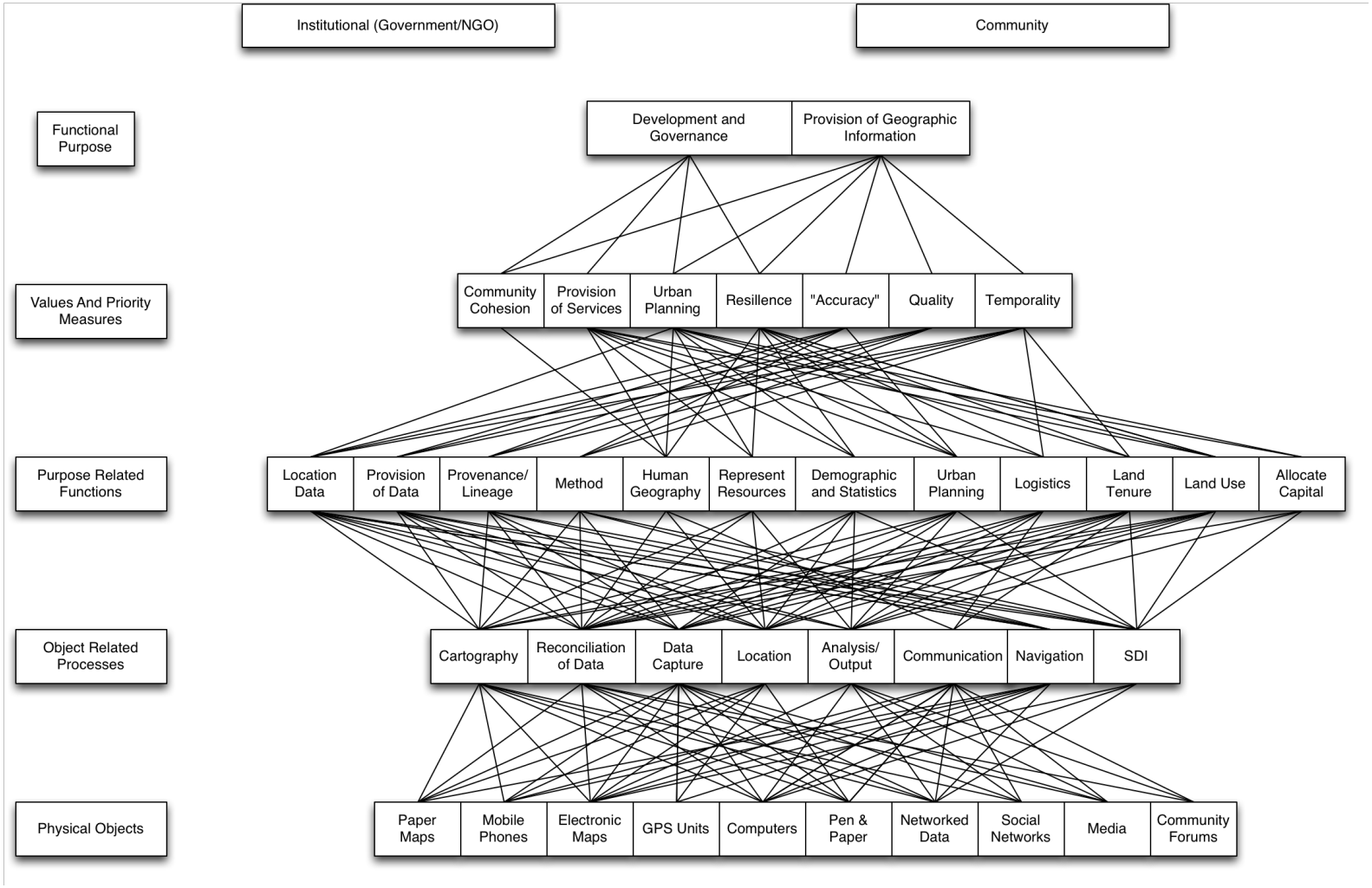


Figure 6.8: Abstraction Hierarchy

Figure 6.8 presents an AH of Community Mapping in IDCs. Ultimately, the **functional purpose** of community mapping in IDCs is to achieve two high level aims the facilitation of *development and governance and the provision of geographic information*. The second level, **values and priority measures** defines criteria to assess if the system is achieving its **functional purpose**. The middle layer, **purpose related functions** joins these two upper layers of abstract concepts with the objects and tools to functions that enable the creation of community mapping. The second level from bottom, **object related processes** define the affordances of the **physical objects** in the system, *"these affordances are tied directly to the physical objects and are independent of the overall system goals"* (McIlroy and Stanton (2011)). On the lowest level are the physical objects of the system, such as the GPS, computers, pens and paper. The relationships between these tiers are not direct, one-to-one relationships; they are interrelational and interconnected in a many-to-many relationship.

This structures enables an understanding of the *means-ends* network (Hajdukiewicz and Vicente (2004)), that describes how concepts relate to each other. The lower levels present the *means* (i.e. the **object or tool**) utilised to achieve the *end* i.e. the **functional purpose** of the system. McIlroy and Stanton (2011) discuss this in terms of a triad of how - what - why. In transitioning between the differing levels of the AH, functions at a higher level provide reasoning on *why* a task is conducted with those at a lower level being resources that enable the functionality of a task, or *how* such task is achieved. For example, for "*cartography*", an object related process, in community mapping, the combination of GPS', mobile phones, electronic maps, computers, pens and paper (as **physical objects**) leads to examining *how* the object of cartography is created. Correspondingly, connecting to this node on its upper tier, providing the *why* you need this node are **purpose related functions**. As such, it is demonstrable that *cartography* enables location data, provision of data, demographics and statistics, land tenure, allocation of capital, urban planning among other **purpose related functions** in the work domain.

In community mapping, this harmonises the relationship between *organisers* who are directly interested in the provision of geographic information with community members who are directly interested in development and governance, leading to **functions** that enable this end, such as urban planning ultimately through the means and object of a community mapper using a GPS in combination with a pen and paper to make notes in the method described in section 5.4.3.3. Importantly, this AH also demonstrates that differing constraints and new technologies can be accommodated through differing tasks.

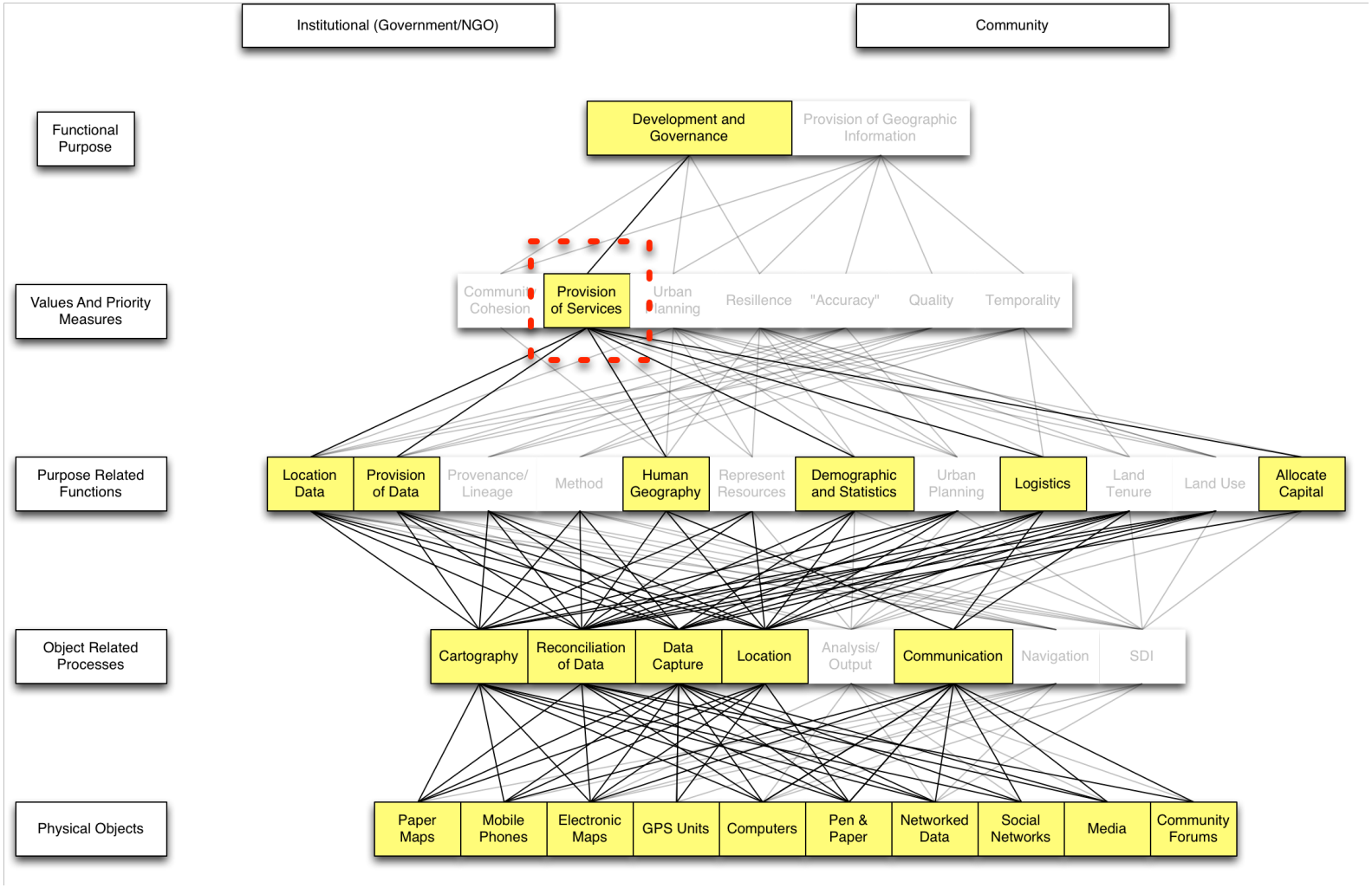


Figure 6.9: AH Identification for Provision of Public Services

In exploring the how to develop new tools or interfaces, it is then possible using the AH to create a *means-ends assessment*, showing the potential and inter-relationships of how concepts could be achieved. For example, in investigating *Provision of Services* (a **Value and Priority Measure**) the means-ends identifies how to achieve this. Directly above the concept of *Provision of Services*, is the **Functional Purpose** of *Development and Governance*. This provides the ends i.e. the purpose of why such a concept exists. The descending connected levels present the *means* i.e. how such concept is achieved, for example *Location Data, Provision of Data, Human Geography, Demographic and Statistics, Logistics, and Allocation of Capital* are all necessary sub-components that aid in delivering the *Provision of Services*. In turn, Cartography, Data Reconciliation, Capture of Data, Location, and Communication are the *means* to support those ends, and so on to the utilisation of **Physical Objects**.

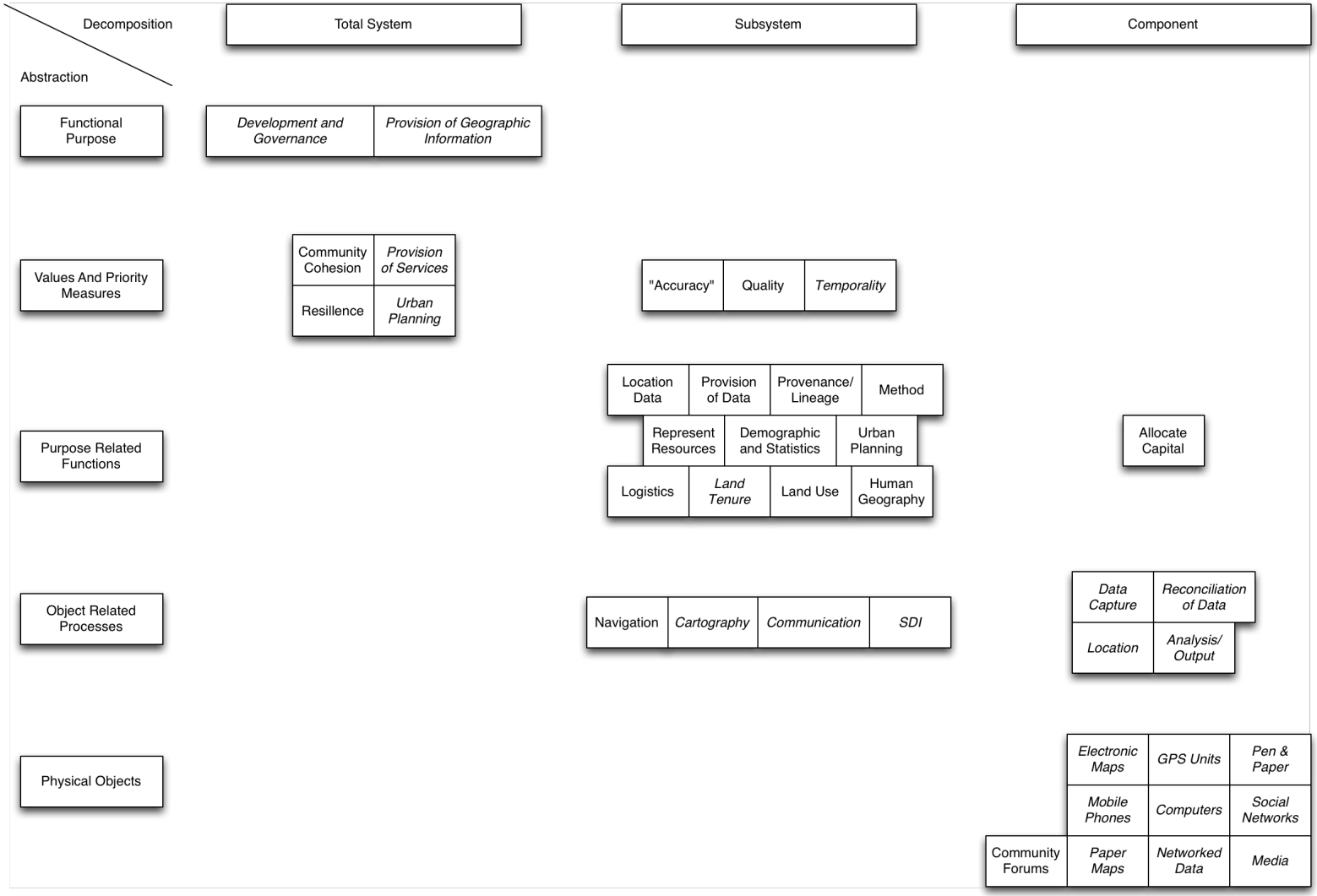


Figure 6.10: Abstraction Decomposition Space

#### 6.4.1.2 Abstraction Decomposition Space

The AH can also be visualised in the form of an Abstraction-Decomposition Space, this is shown in Figure 6.10. As noted previously by Hajdukiewicz and Vicente (2004), this allows the constraints of the system to be assessed. In keeping with the example of Figure 6.9, it is demonstrable that this concept is relevant to the entire system of community mapping. This is evidenced through all interviewees noting the challenge of public service delivery, from Organiser:2 of the first case study: *Typical needs were around sanitation, toilets, waste, rubbish, health, water bodies, malarial, confluence of water access and sanitation points/solid waste collection, security, lighting, business supply chains; these were things we mapped and had a conversation around"*, to Mapper:11 (student) of the second case study: *The waste which is generated from their homes. Whether it's the plastic waste or the foodstuffs. All of them. They just discharge it anywhere. Because since there is no specific place where they could discharge to their waste area. Something needed like landfills from the community discharges"*. While the *"Provision of Services"* is not a sub-component of community mapping, it encompasses the entire system, it is also not the main purpose of community mapping. Similarly, Accuracy is an important **Value and Priority Measure** but is a subsystem of community mapping.

The ADS further supports analysis of constraints of concepts in this manner. The combination of both the AH and ADS provides high-level insight into potential outcomes and opportunities of community mapping and potential for community priorities to be supported through the relationship between concepts.

### 6.4.2 Phase 2: Control Task Analysis

The second phase of CWA, Control Task Analysis (ConTA), considers the recurring tasks that mappers would complete. Naikar et al. (2006) describes the approach to ConTA contrasting normative and descriptive approaches with a CWA formative approach: *"Normative techniques focus on prescribing how work should be done...Descriptive approaches to work analysis seek to understand how work is actually done... CWA, on the other hand, provides a formative approach to work analysis that focuses on how work can be done"*. This is done through the decomposition of control situations and tasks through tools such as the *Contextual Activity Templates* (CAT) and *Decision Ladders*.

#### 6.4.2.1 Contextual Activity Template

As discussed in section 3.2.3.1, Naikar et al. (2006) developed CATs, to decompose work situations and work functions. Work situations are shown on the horizontal axis and work functions on the vertical axis. As discussed by McIlroy and Stanton (2011), *"these situations*

*can be a temporal, spatial or a combination of the two".* Circles show work functions and the box around the circles show the extent of where work functions can occur (as opposed to must) and the bars show which work functions *typically* occur in each situation.

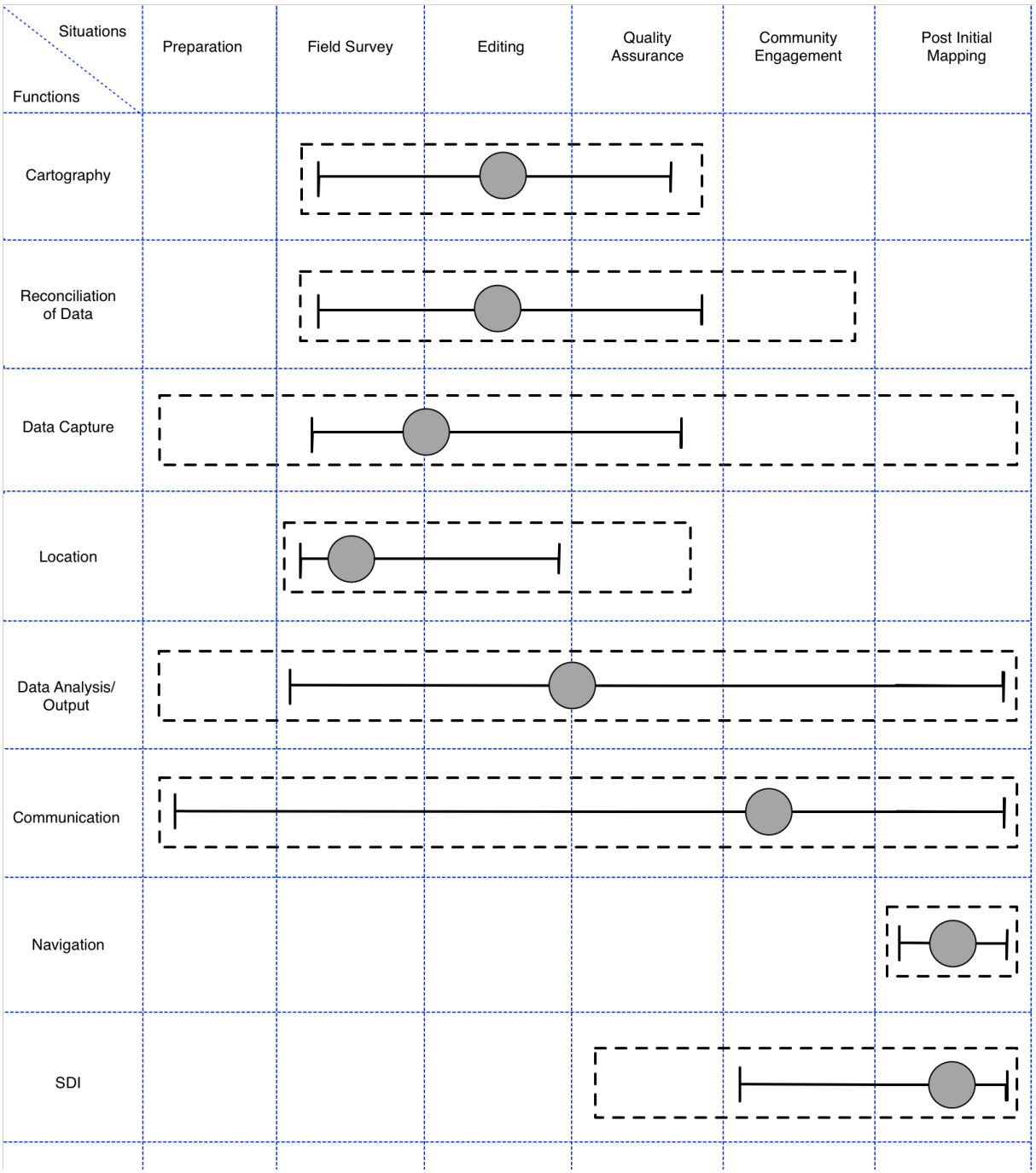


Figure 6.11: Contextual Activity Template

Figure 6.11 constructs a CAT of community mapping, using situations identified in section 6.3.4.1 namely: *preparation, field survey, editing, quality assurance and community engagement*, these situations demonstrate differing spatio-temporal characteristics, in that some are activities that some are temporally continuous, like community engagement evidenced through

the continuous updating of the blog, while others such as the *field surveys* are temporally discrete; mapping occurs and when it's finished, it stops. Functions of the system are also defined through the synthesis of the prior case studies of community mapping imported from the AH described in section 6.4.1.

Here it is demonstrable that for the **function** of cartography, it is primarily **situated** in editing, where it can occur as part of the field-survey (decomposing this potentially through noting on maps) but also *could* occur as part of the Quality Assurance process. To further exemplify this, *data capture* is a process that in ongoing throughout the community mapping **situations**, denoted by the box, but typically exists as a function between Field Surveys and Editing, but also can occur during the **situation** of Quality Assurance.

#### 6.4.2.2 Decision Ladders

As discussed in section 3.2.3.2 decision ladders are used to consider activities in decision making terms (Rasmussen and Jensen (1974); Vicente (1999); McIlroy and Stanton (2011)). This is useful to further decompose work situations and work functions activities, to examine how a task is conducted, within the intersection of the **situation** and **function**.

Within the field surveys, upon observing a feature that isn't mapped, to shunt directly to the state where task, and subsequent procedure definition of how to map the feature is conducted. This neglects assessment of whether such a feature is necessary to be mapped, through the explicit understanding of the situation's goal. The same is true for the leaps that can be effected by understanding the system state (i.e. what features are already in the environment?) that lead directly to either definition of the task or procedure. The selection of the participant of either task or procedure is predicated on their skill level and the tool they are using.

The subsequent decision ladder examines the situations of Field Surveys and Editing, two central activities of community mapping. Community Forums are not a technical activity and as such are not appropriate to be defined in this manner. Decision ladders were constructed through observations of community mappers in the community mapping process, reinforced through the semi-structured interviews in Annex A.

Figure 6.12 diagrammatically presents the decision ladder of the Field Survey and Editing situations, described in section 5.4.3.3, undertaken by the mappers, editors and tracers.

For example, a novice mapper on seeing a water-point which is not yet surveyed would follow the whole ladder, from the Activation box, and progress through the various states of information and decision making, ultimately leading to the survey of the water point, selecting one or a combination of tools, such as geo-tagged photo, utilise a GPS to denote the location, or sketch it on a map.

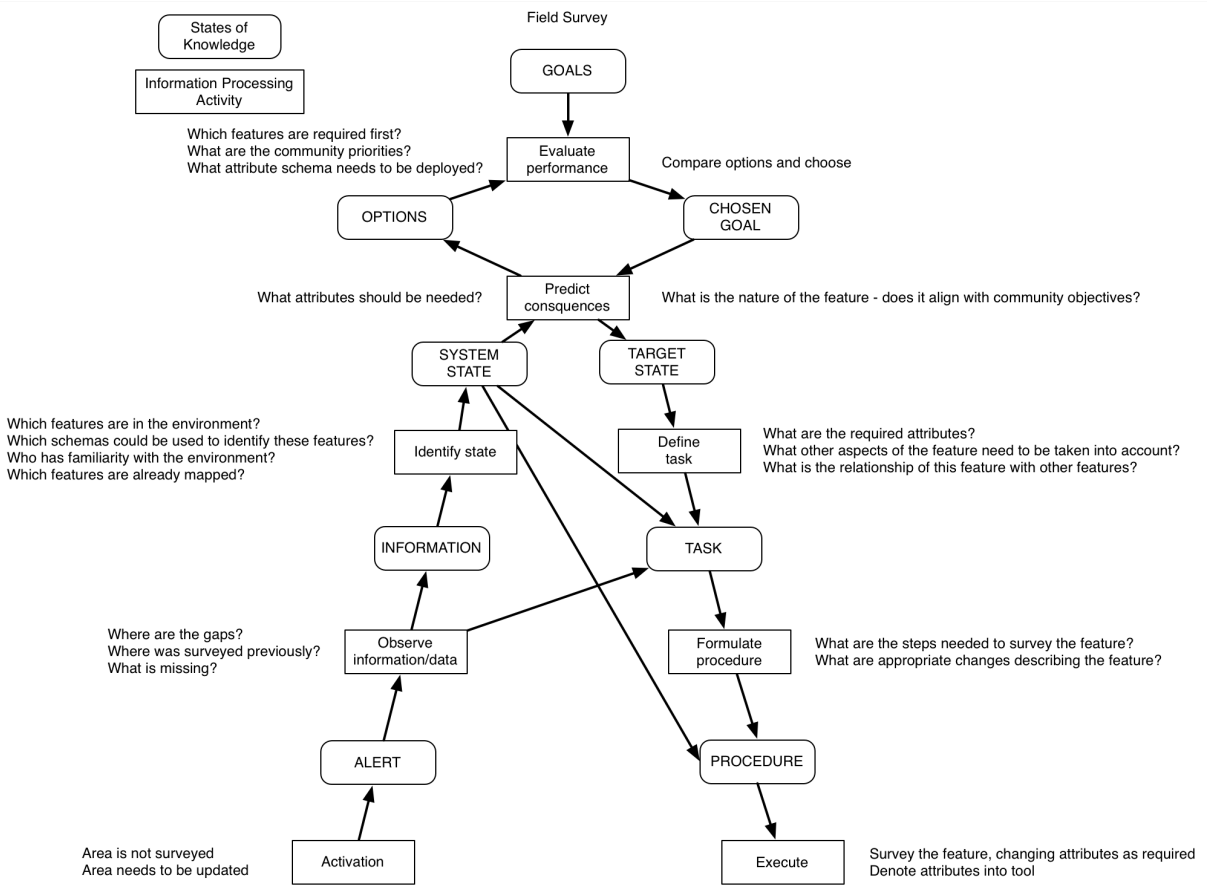


Figure 6.12: Decision Ladder of Field Survey and Editing Situations

A more experienced mapper, based on their prior experiences in the field potentially could leap and shunt at various stages. For example, on observing that a water point is not surveyed, he or she automatically moves to the task or procedure definition and executes the survey using their tool without considering the options or goals of the system as a whole. This approach of non-skilled and skilled mappers and editors, working within the constraints of the system, is examined further by the subsequent phases of CWA.

The editing situation occurs upon the mappers returning from their field survey. The editing tool is selected, data is uploaded, then observed, its characteristics identified by the editor. Here experience of the editor or tracer is relevant, the opportunity to leap to defining the task or procedure exists. It was observed that novice editors would often have to refer to the OSM schema, or discuss system goals with their colleagues. In effect, this requires the decision ladder to be followed completely.

This contrasts with expert editors who leap and shunt towards the execution state based after identifying the system state using their prior experience, both of the characteristics of the data and what they believe the appropriate response is. The expert editors would work almost autonomously, but with oversight from their peers, contributing when necessary.

For a full exposition of the decision ladders of this CWA, these are found in Annex B.1.

#### 6.4.2.3 Synopsis

Both the tools of ConTA, the Contextual Activity Template (CAT) and Decision Ladders demonstrate the functions and situations of community mapping and how tasks are effected by mappers, editors, and tracers. Both tools describe the space in which decisions are made by participants that exist in the roles, and as such are technology agnostic, with decision ladders examining the potential routes of how a task can be executed. In part, this presents a design space for understanding how situations and functions relate to tasks undertaken by participants in community mapping.

Whatever the skill levels of the participants, ultimately the same outcome results: data is collected during the Field Survey by mappers and subsequently Edited by editors and tracers. Upon participants gaining more experience, it was observed they become more efficient and more comfortable with the tools and processes of mapping. It was beyond the reach of this thesis to investigate this further and this presents opportunity for further research[1]. The execution of these situations occurs in a cyclical fashion, upon the execution of the Editing situation data is uploaded to OSM, thus leading to the creation of the map. Yet, there are multiple strategies for achieving the same goals. This is discussed subsequently and is the third phase of CWA.

### 6.4.3 Phase 3: Strategies Analysis

As evidenced in the comparison of community mapping approaches in section 6.5.2, there are multiple strategies that can be employed that achieve the same result. Various factors change how participants select the strategy. It could be based upon constraints of technology access or their own ability (Payne et al. (1993); Vicente (1999); Ahlstrom (2005), McIlroy and Stanton (2011)).

Phase 3 of CWA, Strategies Analysis *"addresses the constraints governing the alternate ways in which activities are conducted"* (McIlroy and Stanton (2011)). Contrasting with the Phase 2 of CWA, ConTA in section 6.4.2.1 which describes activities to be conducted, Strategies Analysis examines how these activities can be performed, respecting the inherent constraints of the system.

> Mapper:11 (Student) illustrates this phenomenon: *"We're collecting data using the GPS and also using the phones for taking pictures for the map of Tandale"*.

[1] Especially the relationship between the maturity/experience of mappers and the resulting quality produced.

Not every mapper had a phone or a GPS receiver, as Mapper:10 (Community) discusses:

*"Using Sketch map, I used my red pen with my notebook, noting the name of the features, which I want to add on the Sketch map, and I draw. If it's a drainage, I draw on the map. If it's a culvert, I draw it. If it's a bridge, I draw it"*. An understanding of these constraints is discussed in section 6.5.1.

As discussed in Chapter 3, the method of presenting strategies is taken from Ahlstrom (2005), subsequently reinforced by McIlroy and Stanton (2011), Cornelissen et al. (2013), and Hassall and Sanderson (2014). Ovals represent the beginning and end states of the strategy, whereas the boxes represent the differing states that the mapper goes through to achieve completion. The strategies examined subsequently conform to the basic data types of OSM, node, way and relation.

#### 6.4.3.1 Field Surveying Node Features

Node data types, represent a point in space These points could be water points or toilets or any feature that exists as a sole feature.

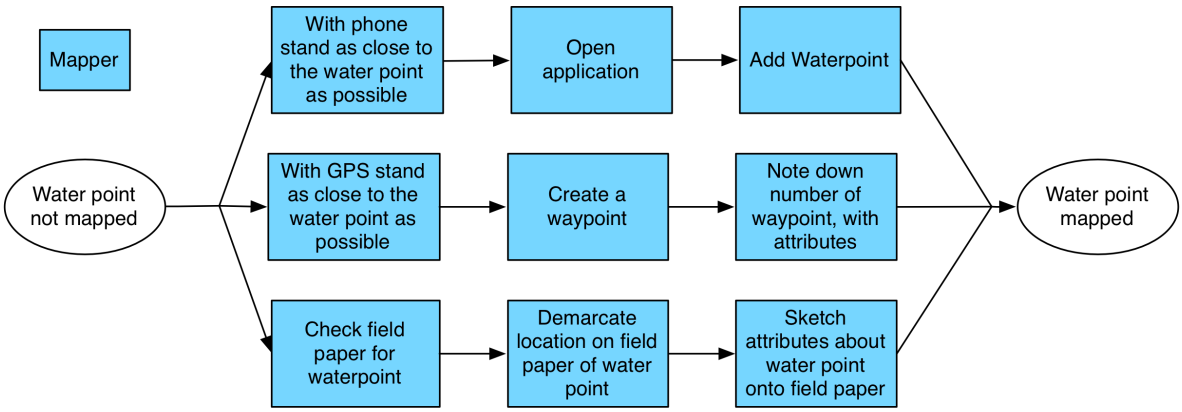


Figure 6.13: Strategies Analysis of Field Surveying a water point

Figure 6.13 expands on Figure 3.6, exemplifying how differing tools achieve the same results, namely the survey of a water point during the Field Survey. Here a mapper is in the field, to survey a water point, they could utilise a mobile phone, a GPS unit or create a sketch on a field paper.

#### 6.4.3.2 Field Surveying Way and Relation Features

Ways and relations in contrast to singular nodes are composed of multiple nodes, joined together. Relations extend ways in that they add another level of abstraction. Whereas ways

denote roads and pathways, relations denote bus routes that run over the roads.

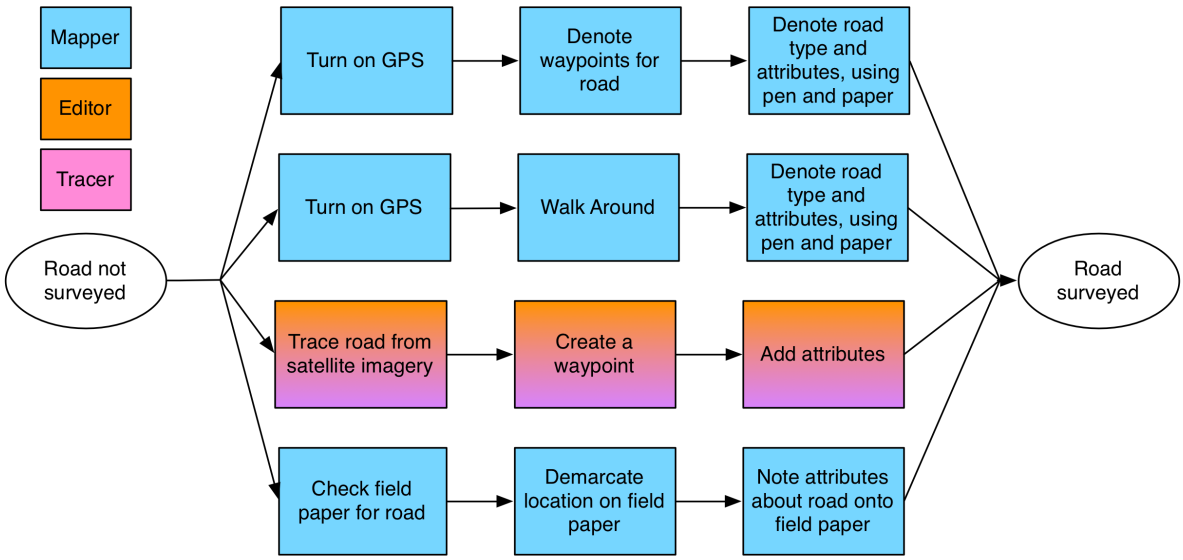


Figure 6.14: Strategies Analysis of Field Surveying a Road

Figure 6.14 examines the strategies that a mapper (and tracer) could undertake to survey a road. For the mapper, differing challenges present themselves on executing through with a strategy, this is due to the tools available and their experience:

> *"It was not my first time to use GPS at Tandale Mapping Project. It was the procedure. The kind of GPS which we were using before is local [old] one. The GPS which used in Tandale Mapping Project it was the modern one. The former [old] it used not to show the path. You just switch on and then you pick them as a point not as a path, not as a way. It is upon you to go and and trace it again. So, by the GPS which we used at Tandale Mapping Project it's different, it's just helping you even to trace where you've passed. It's a little bit few editing of the path. The technology played a big part in mapping project."* Mapper:6 (Student).

This demonstrates how the inclusion of new technology through the community mapping process, changes the strategy of how participants collect data in the field, further demonstrating the formative aspects of this design of community mapping.

#### 6.4.3.3 Editing and Tracing

Editing and tracing is the situation of collecting data from the mappers who conducted the Field Survey, processing it, then uploading. As discussed, in sections 6.3.4 and 6.3.4.1 there was a limited choice of editing tools, not because these tools didn't exist, but due to the external constraints such as connectivity. The result of this, meant that in both cases of community

mapping discussed by this thesis, the same tool of JOSM was used, this indicates a normative approach to selecting a tool, but as discussed in the subsequently and in section 5.4.3.8 this is not the circumstance.

#### 6.4.3.4 Synopsis

Through observations it was demonstrated that differing roles conducted the same task, albeit using different tools and approaches. Figure 6.14 exemplifies this: mappers during the Field Survey situation can choose to use a GPS, mobile phone or sketch out using field papers, pens, and paper a road. Tracers if having access to computers and clear satellite imagery can execute the task and achieve the same end result, regardless of the means. Each is an appropriate strategy for capturing the location and attributes of that water point or road or any other feature, but each participant (regardless of role) has a differing strategy in accomplishing the task, based upon their skill and constraints.

The access and ability to use tools, in environments such as Dar es Salaam is still challenging, this will be expanded upon in this chapter's discussion, extending the generalised constraints of socio-technical systems investigated by Hassall and Sanderson (2014), to include four additional constraining factors relevant for designing community mapping projects in IDCs.

#### 6.4.3.5 Phase 4: Social Organisational and Cooperation Analysis

The Social Organisation and Cooperation Analysis (SOCA) phase builds upon previous phases of the CWA. This is achieved through segmenting tasks by the role who carries out the task and can be applied to any of the previous phases. Vicente (1999) proposes the role segmentation of the abstraction hierarchy and decision ladder through this process, whereas McIlroy and Stanton (2011) use the CAT. There is no current view on the most appropriate method to identify the best situation to use SOCA. In presenting the phases of CWA through case studies, Vicente (1999) discusses that they must have a social component and the originators of the conceptual framework of CWA, Rasmussen et al. (1994b) offers no guidance on this matter. This is out of scope for this thesis, but presents opportunities for further investigation.

Due to this challenge, and the delineation of functions and situations within the CWA, the McIlroy and Stanton (2011) approach was used of combining an understanding of the roles with the CAT. This approach has been taken by Stanton and McIlroy (2012) and Stanton and Bessell (2014). The implications of using CWA, as an emergent method, will be discussed later. Importantly, in keeping with the formative design principles of CWA, this SOCA-CAT describes where roles could be filled by community mapping participants not where roles should be filled. Yet, some roles are naturally constrained and normative; for instance, if mappers do not collect data, editors cannot edit it.

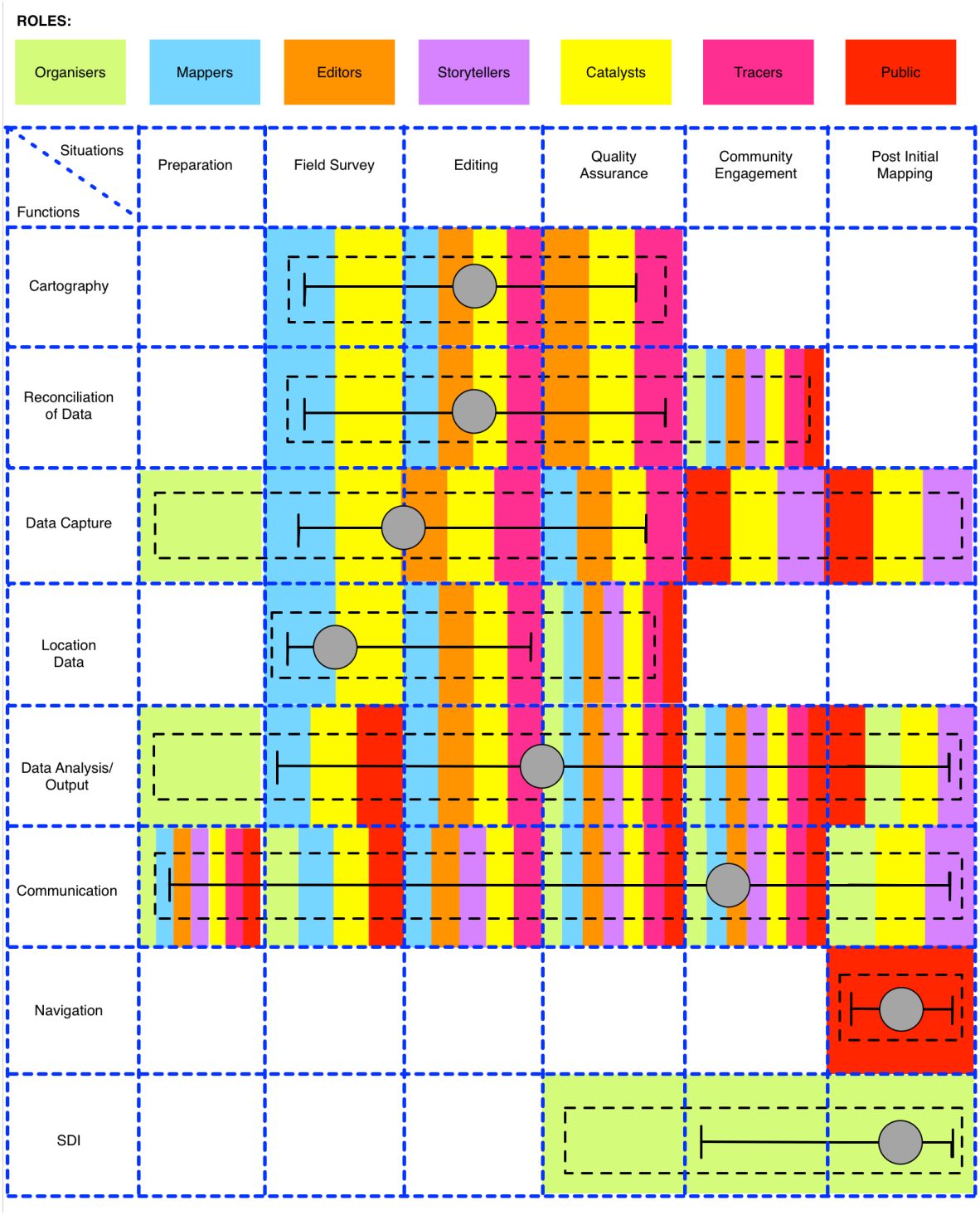


Figure 6.15: SOCA-CAT of Community Mapping

The SOCA-CAT of Figure 6.15 shows the social cooperation between the roles identified by in section 5.4.3.3 and situations and functions identified in section 6.3.4, through the shading of the CAT presented in section 6.4.2.1. Key observations include:

- Mappers while engaging in the Field Survey situation can engage in other situations, such as Editing and Quality Assurance, potentially to clarify features and refine collected

data. This contrasts with Editors whom are distinct from mappers in that they do not engage in the field survey. Though as discussed in section 6.3.4.1, the impact of new tools, improved efficiency, leads to a breakdown in the distinction between editors and mappers;

- Storytellers engage upon mapping being started, not before, though these can continue to engage with the community mapping project, post the initial mapping campaign. This was evidenced by how the community blog has continued[2].
- Catalysers have the opportunity to engage in all aspects of the Field Survey, Editing, Quality Assurance and Community Engagement situations. This demonstrates their value and function of bringing cohesiveness to community mapping, and demonstrates community enfranchisement, indicative of an upwards move of Arnstein's (1969) participatory framework;
- Organisers are involved exclusively in the Preparatory situations of community mapping, bar the function of communication upon which the community forums are held;
- The situation of Quality Assurance and the functions that intersect it are the responsibility of all roles;
- Due to the openness of the data collected in community mapping, another participant role is defined. This being the wider crowd and public. Community mapping exists within the VGI/Crowdsourcing space with data generated by it available to all. It can be utilised for functions of Navigation and SDI. These two functions are not related directly to the praxis of community mapping, but are functions enabled by the data produced and are concepts important to the ultimate resolution of this thesis' research question. This will be discussed further in Chapter 7.

The SOCA-CAT of Figure 6.15 was developed through the synthesis of observations and interviews of Annex A. There is still further opportunity where this could be improved as future work, exemplified by the current lack of understanding of how community media enabled by storytellers can occur prior to the start of the mapping process. Ekdale (2014), discusses the community journalism and communications from the Map Kibera community mapping project and the challenges of community engagement. In a formative system, where participants (i.e. community members) are actively empowered this shouldn't be a by-product of mapping, but a community driven activity.

Similarly, how can catalysers be identified and nurtured in the Preparation situation, as opposed to being emergent as part of the community mapping process? These questions begin to set an agenda for the development of community mapping as a formatively designed work domain, through analysing further the interactions of the community conducting the mapping and those communities supporting it.

[2]see http://tandale.ramanitanzania.org/blog/ for this

#### 6.4.3.6 Phase 5: Worker Competencies Analysis

The SOCA phase four allows for a decomposition of how roles of community mapping can support the situations and functions inherent in community mapping. In keeping with the ethos of CWA, the SOCA is not prescriptive, but showing the situations and functions where participants in the roles could interact as opposed to should. The final phase of CWA, Worker Competencies Analysis (WCA) examines the competencies of those that fulfil the roles, Rasmussen (1983) defines an established model used by Vicente (1999); McIlroy and Stanton (2011) and others, allowing investigation into competencies and the behaviour needed by workers, called *Skills, Rules and Knowledge (SRK)*. Additionally, unlike SOCA, this is not an emergent method, but an established method for eliciting the competencies of workers.

The taxonomy of SRK according to Vicente (1999) is *"defined by distinguishing categories of human behaviour according to fundamentally different ways of representing the constraints in the environment"* (p281). In this, SRK is a taxonomy offering a continuum of progression, moving from Skills through Rules to Knowledge[3].

McIlroy and Stanton (2011) offer guidance on constructing a WCA, in utilising the **Object Related Processes** identified by the Abstraction Hierarchy, then examining the SRK required to fulfil each function. Due to some of the functions of the AH being derived from the process of community mapping and not directly tied to a role, the subsequent SRK taxonomy maps the roles of community mappers to the functions where they make the most contribution.

[3] This is discussed in Chapter 3, in section 3.2.6.

| Object Related Processes | Skill | Rule | Knowledge |
|---|---|---|---|
| Reconciliation of Data (Editors) | Can upload data into editing tool, tag and upload to OSM | Can upload data into editing tool, create nodes, ways and relations with tags and upload to OSM. Resolve conflicts with the data model, as identified by in software tools. | Can upload data into editing tool, create nodes, ways and relations with tags and upload to OSM. Has underlying knowledge of geographic principles such as topology that facilitate improved data editing. Resolve conflicts with the data model, as identified by in software tools. Understands how to transform and define schemas as required by needs of mappers. |
| Data Capture (Mappers) | Can describe and note feature details using available tools | Can describe and note features with respect to their OSM tags | Understands the differing data and tagging schemas used to classify features in OSM and the limit of these schemas, leading to new schema definition. Knowledge of geographic principles |
| Communication (Storytellers) | Can communicate community issues through forums and during activity of mapping | Can communicate community issues through forums, during activity of mapping and through blogs and other communications | Can communicate community issues through forums, during activity of mapping and through blogs and other communications, leading to new strategies and community driven priorities. Has knowledge of community pulse and broader scope of needs. |

Table 6.1: WCA SRK Taxonomy informed by the roles and AH

Table 6.1 presents the SRK taxonomy aligning the functions that are primarily executed by participants in these roles in community mapping. Through the presentation of the SRK taxonomy, it is possible to enable identification of skill gaps within participants, and offer support and further training accordingly. For example, through demonstrating the differing tagging schema options to mappers. This progression by those mappers was described by Mapper:6 (Student), describing the progression of familiarity and use with a GPS:

> *"They didn't know even what GPS is. As far as we students together with the other people. Having [names redacted] [they] assisted them to know first, 'This is the GPS you can switch it on. How you can pick the points.' They were just learning slowly. At the end they come up and they manage to use the GPS. Not all the community members at Tandale they can use the GPS. Only those few ones who we get in the Project. They are the ones who can use the GPS."* Mapper:6 (Student)

It was observed that mistakes will be made at the start of the mapping, as is to be expected. These mistakes can include mappers surveying using their own feature tags, some tags which were already defined in the OSM data schema. As the project progressed, these errors were rectified by the mappers, as the familiarity level with the tools increased, new skills developed and the continuous process of QA, operated as offered by some tools and community mappers.

Notably, the role of catalyser is absent from this taxonomy of SRK, this is appropriate due to the view of this thesis that Catalysers can aid and support community mappers across roles, at times, undertaking that role themselves temporally, as demonstrated in the SOCA-CAT in Figure 6.15.

This presents an interesting question for future research into community mapping. The role and value of the catalyst is critical for interfacing between differing communities, roles, situations, and functions. Rasmussen (1983) discusses that an expert will rely predominantly on Rule Based Behaviour and Knowledge Based Behaviour as their competency increases. As such, this thesis proposes that the catalysers are the culmination of an expert community mapper that is competent with undertaking community mapping tasks in differing roles, situations, and functions.

### 6.4.4 CWA Synopsis

The phases of CWA presented here, deconstructs community mapping as a complex socio-technical system, this is built upon the roles, situations, and functions identified in the previous case studies:

**Phase 1** Work Domain Analysis presents the Abstraction Hierarchy and Abstraction Decomposition Space, it is possible to identify the means and end of community mapping, from

the Physical Objects that can be used (i.e. the means) through to the Functional Purposes of Community Mapping (i.e. the end);

**Phase 2** Control Task Analysis is composed of two models, the Contextual Activity Template (CAT) and Decision Ladders. These both identify common tasks, situations, and functions, showing what needs to be done in community mapping;

**Phase 3** Strategies Analysis, exemplifies the differing strategies that can be employed by mappers to survey certain features of nodes or ways, demonstrating that there does not have to be a normative process for community mapping;

**Phase 4** Social Organisational and Cooperation Analysis, extends CAT by affiliating situations and functions with the roles of community mapping, demonstrating how tasks could be organised and cooperation between community mappers can be realised;

**Phase 5** Worker Competencies Analysis presents a taxonomy of Skills, Rules and Knowledge that can be used to inform the competencies of community mappers. In all of these phases, the analysis is formative; participants in the differing roles could organise themselves in this way, but they do not have to.

This demonstrates the constraints of the complex socio-technical system of community mapping, but allows for community mappers to complete the design.

## 6.5 Discussion

Chapter 5 described a case of community mapping in IDCs, demonstrating that it is a complex socio-technical system, this was further extended by the case study of section 6.3. Utilising observations and interviews conducting through these case studies, led to the construction of a Cognitive Work Analysis (CWA), in presented in section 6.4.

This CWA demonstrates community mapping as a socio-technical system, presenting what Rasmussen et al. (1994b) terms a *"design space"*. This design space can be used to support the design of new tools; this potential is examined in the subsequent chapter.

### 6.5.1 Constraints in Strategy Selection

McIlroy and Stanton (2011), with reference to the phases of CWA and strategies analysis in particular suggest that *"not all stages of CWA may be informative or appropriate"*, citing tasks which by their nature are purely normative - just one normal way. This also has alignment with the comment of Haklay (2013b) on the extent of democratisation, exemplified by the constraint that a complex editing software, such as JOSM was necessitated as opposed to Potlatch due to the latter being constrained by lack of connectivity to the internet. Yet, potential exists for

these constraints to be lifted through improvements to technology alongside improvements to social practices.

This was evidenced in comparing the two case studies of community mapping projects, where Field Papers emerged as a new technology at the time of the initial community mapping project, but was constrained by lack of printers. This constraint did not exist in 2014, in part due to the enhanced capacity two of the organising institutions, COSTECH and the World Bank. As such, field papers could be printed. The use of this tool and it's impact is denoted in Figure 6.3 and in section 6.4.3.5 aiding the mappers by improving their ability to map.

Complementing technical improvements, social practices could be improved through enhanced community organisation and coordination at a ward level. It was observed community members themselves organised themselves very ably when in smaller, subward groups. However, when communicating a coherent message to the Ward Executive Officer at a Ward level, it's hard for the community themselves to prioritise their needs. This prevents full attainment of the upper echelons, and therefore full citizen participation, of Arnstein's participatory framework. This isn't the sole constraint, but is one constraint that requires mediation and intervention both within the community and within the organisers (ie. government).

In discussing constraints inherent to complex socio-technical systems, Hassall and Sanderson (2014) conduct a literature review assessing differing strategies analysis as part of the CWA toolkit and synthesising three generalised constraints that affect strategy selection. These are:

1. Time Pressure: "Occurs when the time available is close to or less than the time required to complete a task". Within community mapping, there was no direct impact of this constraint. Evidently, this is a constraint, though it was not one experienced in the previous discussed case studies;
2. Risk Level: "Is the degree of exposure to harm, loss or another unacceptable outcome". This was exemplified by Mapper:6 (Student) "in the security issues on those streets, there are a lot of robbers at Mtogole, so we were going there but fearing that maybe they might steal our phones, they might steal even the GPS... We were walking with their leaders, others in the group they were leaders of their streets. They were just protecting us, that was one of the challenge[s]". In this, the mapper's strategy was to ensure they were accompanied by community members who would vouch and protect them. It is not known or investigated by this thesis, what impact, if any, this had on the mapping;
3. Difficulty in executing the activity: "Pertains to the challenges posed by the situation and the task of a worker given his or her resources". This is the most complex factor, in Hassall and Sanderson (2014) analysis considering situational, actor, and societal factors.

Extending this third generalised constraining factor, **difficulty in executing the activity** the following constraints are specific to community mapping projects in IDCs:

1. Connectivity: The internet and electricity, while ubiquitous in IACs are still major constraints in IDCs as Mapper:6 (Student) explains: "we're facing with problem of electricity, the power, other times, we're failing... I mean people could just go to the field, but because of the power were going off, we're failing to use computer so the people were not going on". Due to the intersection of offline Field Surveys and online Editing, necessitated for the ultimate creation of the map, these connectivity factors are critical;
2. Access to tools: to be discussed in section 6.5.2 and in section 6.4.3 the changing nature of accessibility to tools and progression of technology influences how community mapping is conducted in IDCs. This is demonstrated explicitly in section 6.3.4.1 where a mapper on receipt of a new phone is enabled to collect roads easier and how Field Papers can improve the collection of ways;
3. Appropriate design of accessible tools: Haklay (2013b) discusses the delusion of democracy in the development of new tools in projects of community mapping, advocating for the inclusion of communities in the design of the tool and necessitating technical intermediaries. This view is reinforced by the exposition of Parker (2012) the motivations of actors in VGI, identifying mappers as being distinct from developers that create applications used by mappers (and editors, tracers etc). The intermediaries already exist to some extent, as described by Mapper:7 (Student): *"My big role in the project was [sic] tech support and [to] teach. And then to transfer the knowledge of me to the community. To teach how the computers, how GPS works, how to use the internet, open an account on the internet, and all that. That was my big role in the project. By teaching the community how this technology works, it helps the whole team making [the] map"*. While this reflection is indicative of how a community mapper starts to become a catalyser, it is not a substitute for tools that are designed collaboratively with the community;
4. Language and communication: As evidenced in Chapter 1, IDCs and informal environments are challenging environments. This challenge is faced by the community residents, with tensions that are difficult to research for those outside of the community, such as the author of this thesis. This is one of many tensions in communication and language adding complexity for outside researchers, but is one also experienced by community mappers as discussed by Mapper:6 (Student) "Sometimes language used to be as barrier. If you can't communicate with them. They don't what you intentionally want to tell them. It is very difficult to understand each other". This demonstrates that even in communities where participants are active tensions will still exist, residents who do not speak the predominant language towards those who do not wish to engage - potentially complicating full citizen participation and acting as a further constraint.

Through understanding these constraints, this allows definition of requirements for tools for environments in IDCs.

### 6.5.2 Mapper's Finish the Design and Citizen Participation

As evidenced by the two case studies of community mapping and by Soden et al. (2014) community mapping has become a much more research orientated domain, with a greater development and use of tools. The initial case study of 2011 observed that the primary tool of data collection was through GPS, augmented by note taking. This contrasts with evidence from section 6.3, where the primary tool used by mappers were "field papers", augmented by GPS as opposed to it being the primary tool. This was due to two factors:

1. Developments in technology: Van Wart et al. (2010) discuss the use of and development Walking Papers (subsequently rebranded as Field Papers). The CWA allows for these objects to be incorporated into the design space of the CWA as they are the means to achieve the end of the functional purpose of the system - namely provision of geographic information and development and governance.
2. Changing Constraints: the development of technology is a factor which communities in IDCs are unlikely to directly influence (due to lack of programming skills) but constraints change as time progresses. For example, the use of field papers was enabled due to the removal of the constraint of printing, with community mappers having access to free printing in this community mapping in this case. These are discussed in depth in section 6.3.3.

### 6.5.3 Synopsis

The CWA design, shows through the choice of participants in choosing tools, such as their mobile phone or Field Papers, that community mapping can be considered as a formative socio-technical system. This aligns with the earlier statement by Vicente (1999) where *"workers do not, cannot, and should not consistently follow the detailed prescriptions of normative approaches"*. This also potentially could address Haklay's 2013 statements on the *"delusions of democracy"* in Neogeographic projects, such as community mapping, where tools need to be designed with communities, not for them. Demonstrably, the appetite exists in communities in IDCs for citizen participation and engagement in civic activities, such as community mapping.

The case studies examined in sections 4.1, 5.4 and 6.3 have generas concepts for VGI created by community mapping in IDCs. These concepts include the *social*, such as Community Engagement, Community of Practice and Community Led-Decision Making. Similarly, Trust, Accessible and Open Data and Dynamic Choice of Tools are important *technical* concepts, that holistically form the socio-technical system of community mapping. This is a simplistic generalisation model, with each of the concepts in the conceptual framework of community

mapping, composed of various social and technical factors and demonstrates the complexity of community mapping. This is discussed as part of the conceptual framework of community mapping in Chapter 7.

## 6.6 Chapter Summary

This chapter presented a case study of community mapping in Tandale, leading to the creation of a Cognitive Work Analysis, that presents community mapping as a socio-technical system and defines requirements and constraints for a formative design of community mapping and tools. As such, the following chapter draws together the results and concepts from the prior empirical chapters, building a conceptual framework to generate a theory of community mapping, answering the research objectives of this thesis.

# Chapter 7

# Discussion

## 7.1 Chapter Introduction

This chapter draws together the case studies and frameworks examined in the previous chapters to answer the research question of this thesis: **What are, the differences between community mapping in IDCs and IACs?**.

To do this, a conceptual framework was created to demonstrate the characteristics pertinent to community mapping in IDCs[1]. This is contrasted with IAC characteristics already identified within the Literature Review of section 2.3.

[1]This chapter has been distilled into two papers so far, one in review to the International Journal of Geographic Information Systems and the other winning the Best Paper award at GISRUK 2017 as *Iliffe, M, Goulding, J and Wimsemius, H. (2017). Towards a Conceptual Framework for Participatory Mapping in Developing Countries. GISRUK Manchester 2017.*

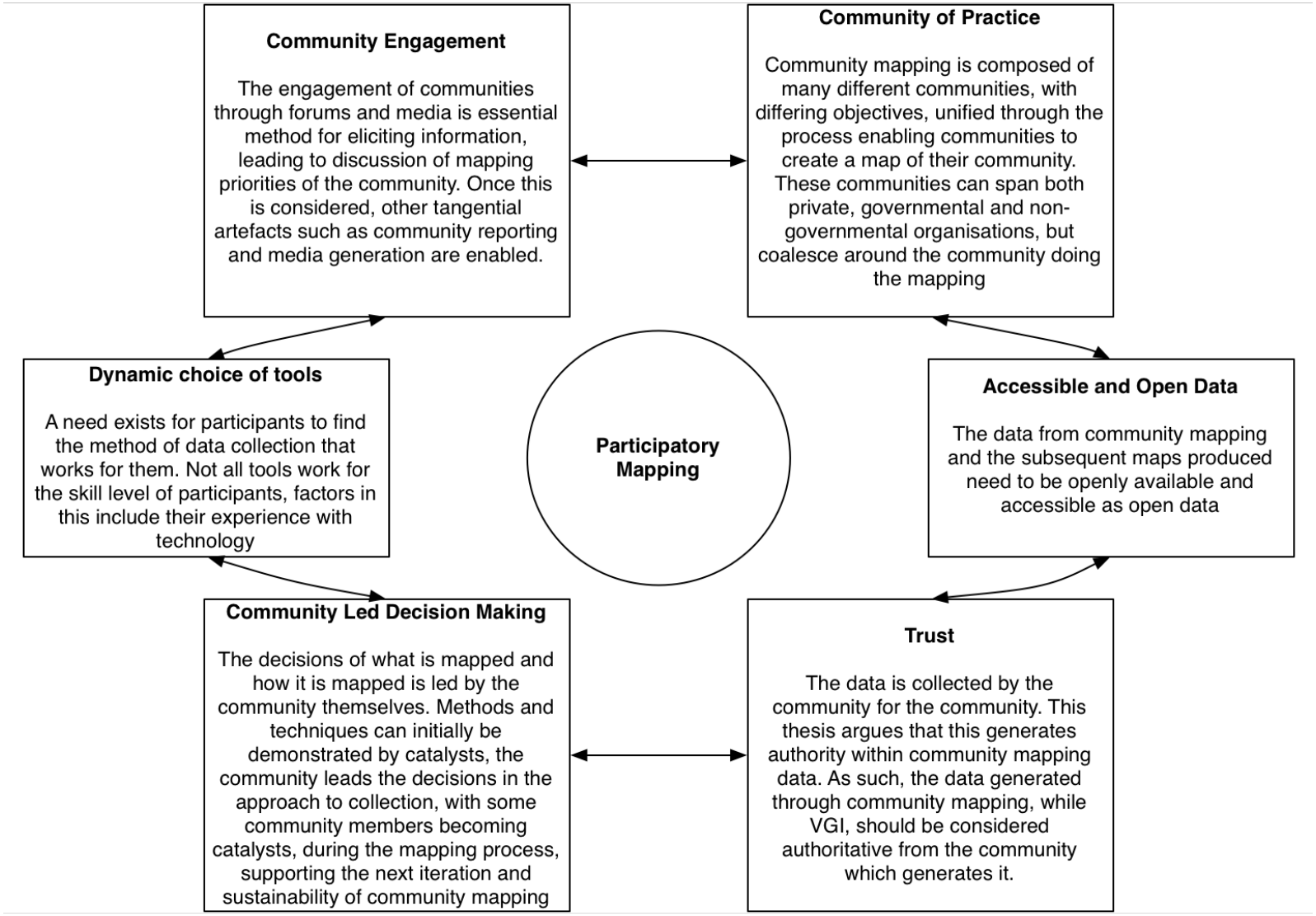


Figure 7.1: The Conceptual Framework of Community Mapping

## 7.2 A Conceptual Framework of Community Mapping

Community mapping enables the collection of VGI to a quality and richness that is previously unseen in Industrially Developing Countries (IDCs). This framework seeks to directly address the research question of this thesis: **RQ: What are the differences between community mapping in IDCs and IACs?**.

The following concepts constitute the conceptual framework of VGI in IDCs:

**Community Engagement:** The engagement of communities through forums and media is an essential method for eliciting information, leading to discussion of community priorities for community mapping. Once this is considered, other processes such as community reporting and media generation are enabled.

**Community of Practice:** Community mapping is composed of many different communities, with differing objectives, unified through the process enabling communities to create a map of their community. These communities can span both private, governmental and non-governmental organisations, but coalesce around the community doing the mapping.

**Community led decision making:** The decisions of what is mapped and how it is mapped is led by the community themselves. Methods and techniques can initially be demonstrated by catalysts, but the community leads the decisions in the approach to collection, with some community members becoming catalysts, during the mapping process, supporting the next iteration and sustainability of community mapping.

**Trust:** The data is collected by the community for the community. This thesis argues that this generates authority within community mapping data. As such, the data generated through community mapping, while VGI, should be considered authoritative in terms of the community which generates it.

**Accessible and open data:** The data from community mapping and the subsequent maps produced need to be openly available and accessible as open data.

**Dynamic choice of tools:** Participants need to find the method of data collection that works for them. Not all tools work for the skill level of participants; factors in this include their experience with technology.

A discussion of these concepts now follows.

### 7.2.1 Community Engagement

Community forums are essential processes to eliciting the requirements and focus of community mapping, through an open forum. As discussed in section 5.4.2.2 this helps raising awareness of the activity, increases enfranchisement of the community as a whole and allowing for whole community participation regardless of being a community resident or public servant. Attendance at these forums does not include all in the community - understanding how to further catalyse participation in the community mapping process will only lead to a better result.

Community forums also enable the dissemination of results and maps, facilitating a discussion and acceptance process, also discussed in section 5.4.4. Amsden (2005) discusses that *"telling stories not only reinforces the collectivity amongst those involved, but the end product presents a snapshot of the community as the community sees it"*. This aligns with towards the upper middle rungs of Arnstein's ladder of citizen participation, where the community is moving towards full control "analogous to 'Citizen Control' in the framework of participation" due to the storytelling work of the blog, which has continued much longer than the initial project, where the blog has taken up the community voice.

In IACs this process is similar, though the engaged community are not co-located in the same area, they are spread out across the world. Missing Maps[2] has emerged to be a global community that uses community organisers to catalyse the mappers in *Mapping Parties*[3]. Parker (2012) also considers the case of Mapping Parties in Leicester, identifying similar roles that this research has identified, in mappers and organisers that help catalyse a wider effort. This is indicative of the transferability of the research in this thesis to other IAC and IDC environments and demonstrates that the characteristics of mapping communities in both contexts can be similar in both remote (Missing Maps) or in co-located (as per Parker's research) contexts.

### 7.2.2 Communities of Practice

Community mapping is informed by and supported by multiple communities, not just the one being mapped. These communities can cover international development agencies such as Twaweza and the World Bank, Academia, such as Ardhi University or local community organisations such as CCI. These communities interact with differing objectives, for some the objective is the training and skills buildings of students, for others the motivation focused around the provision of improved public services, evidenced in section 5.4.2.

[2] http://www.missingmaps.org/ - organised by the Red Cross, Doctors Without Borders and others.

[3] Similar to the daily mapping that occurs in community mapping, but done remotely usually over a period of one to tow days.

For example, from the perspective of the World Bank, the project was given the name "Urban Community Mapping" World Bank (2013), as opposed to the subsequently used Ramani Tandale. This is indicative of the broad range of ideas and motivations within the institutional stakeholders that provided the monetary and institutional support for community mapping. This also presents potential for tensions between stakeholders; as mentioned the World Bank considered that the data collection was paramount for understanding the implementation of their projects, whereas SURP wished for skills building and training for its students. This is a common feature, for example, in interviewing one of the organisers of the project:

> *"[There is a ] Long way to go to operationalise community mapping, a lot of bodies are not comfortable with how this tool can benefit them. A lot of barriers to the notion that this information can live in the public domain"*- (Organiser:3).

In contrast with the community catalysers:

> *"The aim was for the community to be highlighted how the maps can solve their own problems. The moment we went to the map there, the community showed us the point of interest, we showed them how to map the point of interest. How to use the map to solve the problems they have in the community?* - (Catalyser:4).

Tensions like this are not insurmountable, but illustrate the potential for challenges and the need to further understand the various objectives of community mapping, especially as each organisation is important within their own domain, potentially with competing internal objectives. From the profile of the stakeholders and their motivations, it is clear that not one institution could have supported, coordinated and assisted the Tandale community with the community mapping campaign, each are dependent on each other. This illustrates that a community of practice[4] is essential to the undertaking of community mapping in IDCs, further illustrating the need to treat community mapping as a socio-technical system.

These communities of practice include the community being mapped, but also include those in civil society, government, and due to the unique circumstances of IDCs, international development and parastatal organisations such as the World Bank and national/local government. This offers a differentiator between counter-mapping, in so much as the government and by extension parastatal organisations are directly involved and supporting the community achieve citizen control, enabling mapping, as opposed to countering it. Here, each stakeholder in the community of practice provides a differing skill and resource set, from universities with

[4] As the successor to the Ramani Tandale project, Ramani Huria now works with several partners to conduct mapping and utilise the maps created. Partners include, Tanzania Commission for Science and Technology, The University of Dar es Salaam, Ardhi University, The City of Dar es Salaam, Buni Innovation Hub and Humanitarian OpenStreetMap Team (HOT) supported by The Global Facility for Disaster Reduction and Recovery (GFDRR), the Red Cross and The World Bank. This group is, as of Q1 2017, in the process of forming a secretariat to help support and guide community mapping thorough the city - this will also include community leaders to build-in equitable participation.

technical skills and community members identifying features and issues relevant to the community.

The building of these communities of practice allows for a multitude of objectives to be met: from developing the skills of the mappers, incentivising them by providing an outlet for describing the problems that they face in their communities, to the provision of data that could be potentially used to improve public service delivery. In interfacing with IAC communities, potential exists for co-creation, where a delineation between IAC and IDC communities in terms of VGI generated. IACs, not constrained by internet connections and electricity could focus on the digitisation remotely; whereas IDC community members could focus on thematic mapping of drains and shops not captured by aerial imagery.

### 7.2.3 Community Led Decision Making

At all stages of community mapping, from the community forum, through field surveys to editing the community mappers lead the decision making. At first this process is supported by organisers and catalysts but as skills, knowledge of the tools and the effect of their utilisation in creating the map, develop the community mappers in taking control[5]. Within the framework of citizen participation this is indicative of citizen power. At the start of the community mapping process, through catalysts, a partnership (the sixth level of citizen participation) exists between the catalysts and community mappers, as skills and confidence are built this becomes delegated power, leading to full citizen control, the final rungs of the ladder of citizen participation respectively. This is evidenced in subsection 5.4.2.2 regarding the community forum process and subsection 5.4.3 with respect to mapping and editing in respective sub-subsections. The decision making at community level is important, as it provides space for the community to prioritise what they wish to map, based on the challenges of that community:

> *"We already know where the problem is. It's all about coming together all the stakeholders [then ]deciding what to do... It involves the indigenous people. The people over there, there are the one who are the key stakeholders of the project. That means that the project will be most sustainable for the people they know much about the project. If you can really change the project, the people can... I discovered issues about Tandale. I'm the one who discovered several issues with sanitation. Things about poor infrastructure. The issue about poor housing condition in Tandale. Issue about water. Water is a big problem in Tandale. Several issues I discovered over there. I wrote a report about it ... For the project to be more sustainable. For the sustainability of*

[5]This also requires that all equipment becomes usable by the community following the initial mapping campaigns, this is a limiting factor in achieving the upper levels of Arnstein's participatory framework. Alternatively, as smart phone technology becomes more ubiquitous, understanding how tools community members have already can be leveraged.

> *the project community members should be involved fully* - Mapper:5 (Community Mapping).

While providing a lens for the community to collect differing thematic features, there are various by-products, namely further enfranchising the community members in the process, potentially making the project sustainable and allowing for continuous quality assurance:

> *"I remember one day, we were from the field and we were uploading, so for the moment I start tracing the data. Others instead of tracing were deleting some of the data"* - Mapper:7 (Student)

Events such as this provide points where mappers stop, discuss and form decisions about how to proceed. This community driven decision making ensures that the map is reflective of the challenges that are faced by the community. This further indicates the complex socio-technical nature of community mapping, but also has implications for the authoritativeness of this data.

### 7.2.4 Trust and Authoritativeness

As discussed in Chapter 2, trust and authoritativeness is an important concept in geospatial information. Data from NMAs is inexorably linked to the authoritativeness of these institutions, and by extension how usage of such data can be trusted. This question of trust in the data is embodied in researching the quality of VGI. Haklay et al. (2010); Koukoletsos (2012); Zielstra and Zipf (2010); Neis et al. (2012); Girres and Touya (2010); Graser et al. (2014) all compare VGI with an NMA dataset with the implication that NMA is of a higher quality, therefore more fit for purpose and trustable. As Chapter 4 has already demonstrated and discussed, the notion of authoritativeness in VGI in IDCs is challenged as no higher quality NMA dataset exists, when testing VGI data from community mapping against an authoritative one, the community mapping data was of a significantly higher quality. This is compounded in IDCs through to the unique challenges of maps in IDCs discussed in Chapter 1.

At a base level, some data and/or map is better than no map. Yet, in community mapping, the data is collected by the community, and then used by the communities, through their own decisions and collection technique. Coleman (2013) discussing the nature of authority in maps, citing the NMAs of the UK, Netherlands, and others, though lacking case(s) of IDCs, further adds credence to Coote and Rackham (2008) term of *"conventional"* data. Conventional is proposed to be a *"more correct"* alternative for authoritative datasets, suggesting factors such as copyright, *"collection by professional staff"* and *collection based on established methods, standards, specifications, and practices*. However, conventional implies that a NMA dataset exists, to these standards, as discussed in Chapter 1 and Baker (2011), this is an incorrect assumption as IDCs have different characteristics addressed by this framework and the Cognitive Work Analysis of Chapter 6.

In discussing potential harmonisation between the conflict of VGI and authoritativeness, Coleman (2013) proposes to assess the credibility of contributors, echoing Flanagin and Metzger (2008). In community mapping, this credibility is a core component of the process, demonstrated by a common refrain from interviewing participants: The *"community knows Tandale"* Mapper:5,6,7 Organiser:2, Catalyer:1,4. More directly, *"We were walking with their leaders, others in the group they were leaders of their streets"* Mapper:6 (Student).

This is amplified by this exchange with the Kinondoni Municipal Town Planner and the Ward Executive Officer, key persons responsible for city planning and ward management respectively, during the Africa Open Data Conference, on the 4th of September 2015[6].

> **Osiligi:** "Frankly I need more effort to be operative with the Office of City Planning; because without them I can do nothing. They have the expertise to plan some areas, and in planning we need a lot of things. We need maps. Tandale, we don't have a map. People build whatever they want in any place. People build in the areas where the floods are too... when it rains, water is going there very fast. So, me and my office and the office of City Planning should collaborate in order to make the new plans and to create some infrastructures which are friendly to the people Tandale."
>
> **Mark:** "What sort of collaboration do you mean? Talking about what it was like without community mapping, how does the Ward of Tandale work with Kinondoni? Could you explain a bit about Tandale ward and Kinondoni, what they are?"
>
> **Juliana:**"Before community mapping, it was very difficult to educate the people of Tandale, or to let them understand what we were talking about planning. But with community mapping, we grow with them step by step, they see their role, we talk to them, they see the problem, we identify the problem together with them, and it becomes easier for them to understand. Even after having the maps on a table, just like these ones, they will see where they belong, where the problems are, and where we have open land for maybe putting ward collection points and putting other services."

This exchange demonstrates how the VGI, created through the community mapping process is starting to influence decision makers and be treated as if it was authoritative. It also cross-validates the concept of communities of practice, through community members participating and creating maps, to the building of institutional capacity, through improved access to Geographic Information.

[6]https://markiliffe.wordpress.com/2015/09/10/data-driven-governance, video released as open data, CC-BY-SA 4.0

### 7.2.5 Accessible and Open Data

Data from community mapping needs to be accessible and openly available for all. This is for two goals:

1. **Community Enfranchisement**: For full citizen power and participation, accessibility is important. Withholding data is a discriminatory act, meaning that the community as a whole would thematically be at the lower rungs of the participatory ladder, not a positive outcome. Through consistent engagement, such as community forums, to individual choices on what is collected and how, the community begins to own the process of community mapping and control it.

2. **Accessibility**: Baker (2011) presented the challenges of data collection in IDCs in conducting statistical analysis for governmental purposes, finding that data was non-existent. Demonstrated in this case study through community mapping of Tandale, part of this gap is now bridged, albeit for a small geographic area, and this could be extended.

From the community perspective, Ramani Tandale *"involves the indigenous people. The people over there, there are the one who are the key stakeholders of the project. That means that the project will be most sustainable for the people they know much about the project*" Mapper:5 (Community). This openness and spirit of collaboration is also shared by the local officials that support Tandale, for example the Ward Executive Officer: *"This map has been [sic] putting in the website. If you want to update, you can update, and I've got the knowledge. They teach me how to add other things, the new house, the new location. Yeah, I can do it"*. This demonstrates that differing roles that are enfranchised through community mapping, from community members, to their public officials

Following the conversation of subsection 5.4.3.7, the exchange continued to include notable comment on the need to harmonise the datasets that they had available:

> **Mark:** "In your professional opinions, is this data authoritative?"
>
> **Juliana:**"In my professional opinion, yes, because this is really data. This is really data, this is the best map, this is the recent best map ever for this area, so I think this is really official and because it belongs to the community, and whenever you want to succeed in the community, like us, we are local authority, we are working with the community"

This presents a promising validation for community mapping, as a methodology to collect data that leads to positive outcomes for governance, not just in terms of contributing to theoretical knowledge of VGI. Understanding how community mapping data is subsequently used presents a future work opportunity.

Thus: the community map is authoritative in the community's own terms. After progressing through the decision making process for what is mapped, feature collection and editing the data is quality assured. As such, this thesis takes the view that the community is its own authority and should be trusted to collect their own data.

Enfranchisement of the community is enabled and facilitated by access to the data. This thesis advocates that once governance institutions see the potential of open data, they will release more data. This is exemplified through Ramani Tandale, which eventually led to the release of city wide geospatial data, covering buildings and roads in 2012; the data used in Chapter 4 to assess quality metrics in IDCs, ultimately leading to the prior case study. In moving from a scarce data environment to one that is data rich, this encourages openness of data, but is not without challenges as commented by Organiser:3: *"A lot of barriers to the notion that this information can live in the public domain*. Davies and Bawa (2012) further discusses the challenges of opening government datasets, with potential for improving *"partial, incomplete and unreliable* government data. This is challenging in IDCs, due to the governmental desire to present themselves (and their data) in a positive light, often, as Stoler (2002), notes deciding to not release data due to deficiencies and quality issues in the data as opposed to a need to protect personal or classified information. Yet Ramani Tandale provided the start of data sharing in Tanzania and other community mapping projects globally, for example through the expansion of the Ramani Huria community mapping project across Dar es Salaam[7].

The two concepts of community enfranchisement and accessibility are symbiotic; through enfranchising the community, data is generated as a process of community mapping. Accessibility to this data presents opportunity for community to engage with public institutions, demonstrating where issues are in their community. This is exemplified in subsection 5.4.2 simultaneously allowing public institutions the opportunity to respond to and resolve these challenges. This is only made possible by having an accessible Geographic Information.

### 7.2.6 Dynamic Choice of Tools

Resolutions of this challenge are integrated into the conceptual framework of community mapping, developed from the Ramani Tandale case, through ensuring accessible and open data and a choice of tools. This was exemplified through ensuring that notices of community forums were distributed widely, paper maps were printed and made available and left accessible for residents and ward officers.

Similar to the findings of subsections 5.4.3.7 and 7.2.5, the created maps can now be used to examine constraints within the community environment. This indicates a constraint of

[7]How the data from community mapping is reused will be demonstrated with respect to improving public services remains an avenue for further research, this is explored further in 8

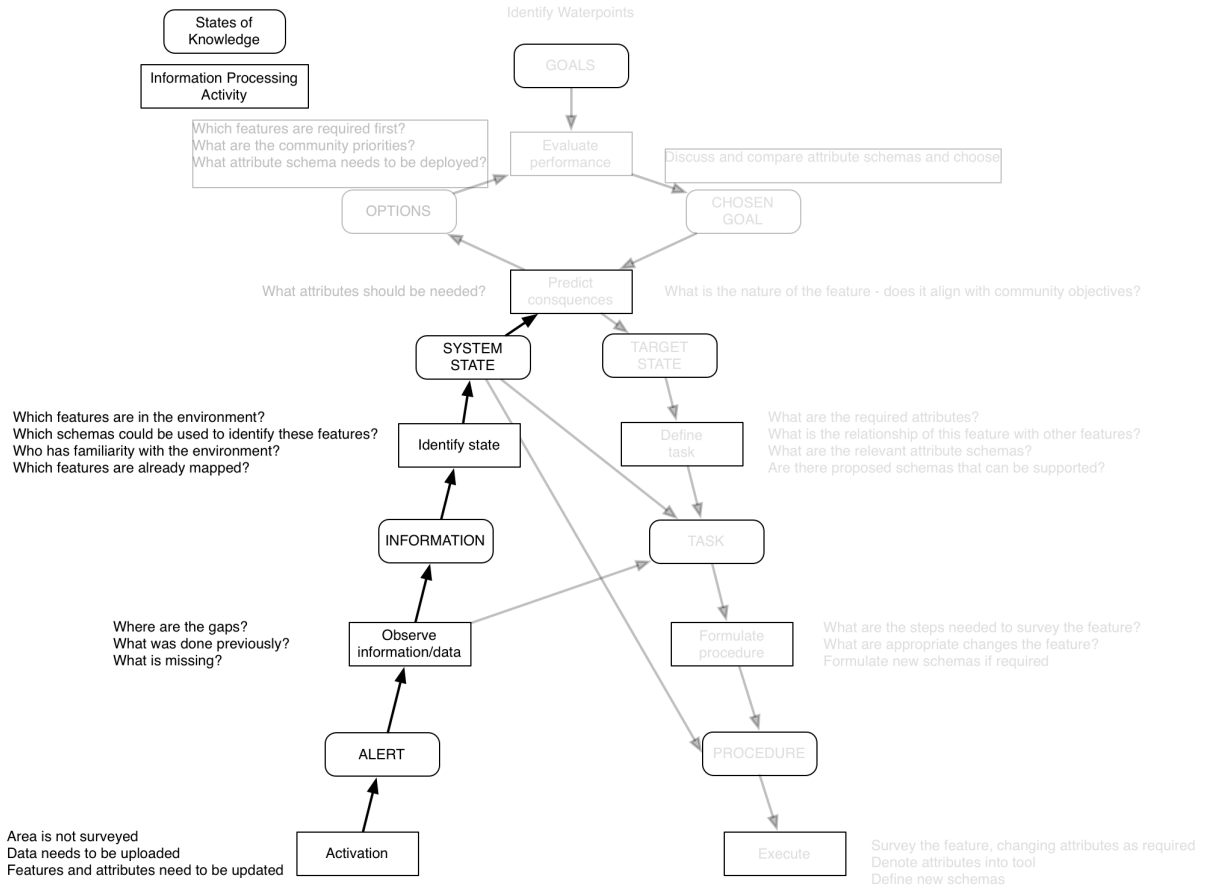


Figure 7.2: Decision Ladder Demonstrating Constraint of Public Services and Potential Actions for Municipal Authorities without Community Mapping

knowledge. Figures 7.2 and 7.3 demonstrate the change that VGI data, generated through community mapping has removed constraints of lack of knowledge, leading toward informed decision making for the placement of public services, also demonstrating of the efficacy of the CWA of Chapter 6. Here the decision ladders show the states of cognition available to authorities, prior and after the creation of the community map.

Each community of practice, the local one in Tandale and the global OSM community (such as those of Missing Maps and Map Kibera), has a different interpretation of full citizen control and democratic power. It is reasonable to suggest, and has been observed, that community members in informal environments such as Tandale lack the technical skills to code tools to support community mapping. Likewise, developers potentially would approach the mapping of such communities like Tandale with an ethnocentric perspective. To bridge this gap in the democratisation Haklay (2013b) proposes an agenda: *"to fulfil the democratisation potential of neogeographic practices, a concerted effort is required to integrate new groups in society in the design and development of technological objects and systems, and an ongoing effort to reach out to those who are underrepresented.* This agenda is also advocated by this thesis. This is especially relevant to communities in IDCs and as such, this challenge was specifically addressed in Chapter

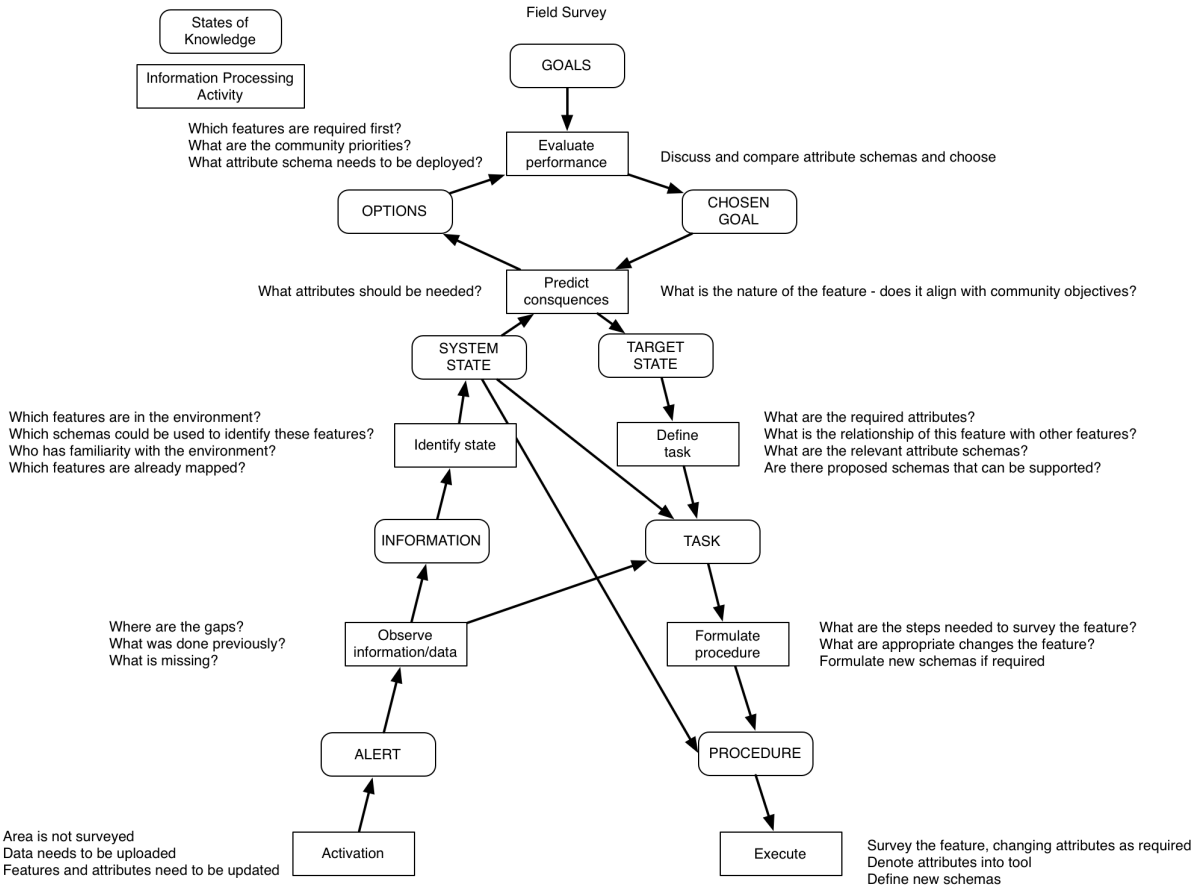


Figure 7.3: Decision Ladder Demonstrating Constraint of Public Services and Potential Actions for Municipal Authorities with Community Mapping

7 through the Cognitive Work Analysis. This further supports the concept of dynamic choice of tools, based on the constraints present in the community at the time of mapping.

### 7.2.7 Framework Summary

The empirical research, led to the conceptual framework of community mapping. This conceptual framework is mostly driven through empirical research, both observational and through interviewing community mapping participants, firstly through observing and identifying their roles, then interviewing a subset of each role. This synthesis of these two approaches in this cross-sectional case study was then augmented through desk review of existing and subsequent literature.

Each of the cases in the Philippines, Indonesia, Mongolia, (Haklay et al. (2014)); Nepal (Haklay et al. (2014) and Soden et al. (2014); and Haiti Soden et al. (2014), Crowley (2014)), exemplify components of this thesis' conceptual framework of Community Engagement, Building Communities of Practice, Community Led Decision Making, Trust in the data, Accessible and

Open Data and a Dynamic Choice of Tools, further validating the conceptual framework.

As data gets accepted by governments and citizen participate in creating richer, thematic quality data, opportunities exist to understand how such data could be used to support traditional government statistics and governance, whilst supporting community initiatives.

## 7.3 Differences between IACs and IDCs

The concepts discussed above illustrate the IDC use case, to recall the research question: *What are the differences between community mapping in IDCs and IACs?*, this section will discuss these differences, with reference to the conceptual framework above, towards setting a broader future research agenda.

### 7.3.1 The Rise of Global Community Mapping Initiatives

The relevance of the Map Kibera project to Ramani Tandale (and subsequently Ramani Huria) and the relevance of both projects to the global movement and subsequent growth of community mapping projects in IDCs globally cannot be understated. Prior to these projects, theoretical groundings of community mapping focused around counter-mapping in IDCs as discussed by Peluso (1995) and Harley (1988) through examining of how states utilise cartography and maps to project and present their power. Map Kibera started to change this dynamic, in engaging local communities in Nairobi, Kenya.

### 7.3.2 Map Kibera

Map Kibera is cited by Hagen (2009) as a modern inception of community mapping, this is reinforced by Shkabatur (2014) upon taking a longitudinal view of community mapping projects from a practitioners' perspective. However, the cases of Hagen (2011) and Shkabatur (2014)) are flawed, as *"community mapping necessitates involvement of all parties, including government"*, as such Map Kibera is different from Ramani Tandale. This was observed by Catalyser:1, a community mapper in Map Kibera: *"In Kenya we did not involve the government. [In] Tandale we did. By involving them from the start they can be able to have an idea of the needs of the community"* .

The process of creating the community map involved the collaboration between residents of Tandale, their local government representatives (and those at a national level) and other international organisations. This differs to Map Kibera which was mainly driven at the start

by two citizens of the USA, Mikel Maron and Erica Hagen, with communities of practice being built in Kiberan and local developmental communities as the project progressed. In the Tandale case, which was initiated locally, albeit facilitated by a development organisation, such as the World Bank, through the exchange of catalysers from the Kibera to Tandale and now to the larger area of Dar es Salaam. This exchange catalysed the community mapping process, with the added benefit that citizens and government were working together, as opposed to apart from each other. As such, this thesis advocates that pluralism is a necessary component for community mapping; if one group such as the government is excluded, then potential positive impact is diminished.

### 7.3.3 Towards a Global Movement

Through building communities of practice with a diverse set of stakeholders, this sensitises the process of community mapping, within the participating organisations. For example, the World Bank from supporting the Ramani Tandale project in its execution in 2011 - planning it started earlier in 2010. This laid the foundation to community mapping being institutionalised as a tool for collecting map data. This is now exemplified by projects in Philippines, Indonesia, Mongolia (Haklay et al. (2014)), Nepal (Haklay et al. (2014) and Soden et al. (2014)), and Haiti (Soden et al. (2014), Crowley (2014)) and in a wider scope back in Dar es Salaam[8].

Additionally, the lack of data and methods has now changed been overcome with Shkabatur (2014), Crowley (2014), Forni et al. (2014) presenting practitioner field guides to community mapping. Soden et al. (2014) go a step further, examining the transition from crowdsourced crisis mapping to community mapping, examining the case of Haiti earthquake.

In non-crisis scenarios, the narrative of community mapping globally subsequently turned to one of resilience to disasters, enabling planning and resilience activities. This is exemplified through Crowley (2014) presenting a case study of the capital city of Indonesia, Jakarta discussing how community mapping is used to provide a map for flood and disaster resilience. In Dar es Salaam as of 2015, community mapping has been repurposed from being utilised as a tool for map creation and skills building to one of flood resilience, with the floods of 2011, considered by the *"TMA [(Tanzanian Metrological Agency)], [as] the heaviest rains Tanzania experienced since independence in 1961"* - BBC (2011). This once in a generation occurrence, occurred again in 2014 (UNOCHA (2014)) and in 2015 (Ramani Huria (2015), Davies (2015)). It is beyond the scope of this thesis to comment on the effects climate change, especially in unplanned dense urban environments such as Dar es Salaam. The trend locally for Dar es Salaam and in other global cases demonstrate the need for maps to counter flooding and other disasters to build resilient cities through planning, which leads to construction of infrastructure,

[8] ramanihuria.org

to mitigate flooding for example, by communities and government working together to clean and remove solid waste from existing drains and build new drains where they are needed in flood prone areas.

Balancing these local projects are international initiatives like Missing Maps, where remote mappers collect data to digitise other areas in IDCs as a collaborative activity. Primarily, the participants in this approach are based in IACs, but generate data for IDCs. This mirrors approaches discussed by Parker (2012), when considering a mapping party in Leicester and how *tracers* work locally within IDCs and how *catalysers* initially parcel up mapping tasks to catalyse mapping. From this, factors between IDCs and IACs in terms of mapping reduce to the scale that can be achieved and the constraints of the local environment. Accordingly, an opportunity for future research would be to further test how the CWA of community mapping applies within the IAC context, building on this thesis, Carver et al. (2001), and Parker (2012).

#### 7.3.3.1 Democratisation?

The emergence of research into VGI coincided with a rise in research interest into the authority in geographic information. Previously, in the generation of maps and geographic data, authority did not need to be questioned, only professional and skilled cartographers could make a map. Through VGI and community mapping, demonstrated through Ramani Tandale, residents in one of the most socially complex environments, an urban slum, can collaborate as a community to create data, leading to a community map. This is a democratisation of data collection, but is not a democratisation of cartography. The distinction between the data and cartography is nuanced, but in tools such as OSM, the barrier to change the cartography and transform data into the map is complex and beyond the reach of everyone but the most technical and enfranchised. This argument is presented in an analysis on the delusion and limitations of democratisation in Neogeography by Haklay (2013b). He cites the case of Map Kibera, as *"the level of intervention in and change of technical codes required becomes more significant, and the number of people who have the necessary skills and knowledge, the interest in making the changes, and the time and resources to carry them through, decreases. So, while the potential for meaning hacking is open to almost any person who can access and use the web (and this already excludes many individuals), the impact of such action is most likely to be limited and local"*. Commonly in community mapping, as exemplified by Haiti, Map Kibera and Ramani Tandale (and others) the *de facto* VGI data repository is OSM.

An open source project, two of OSM's (OpenStreetMap (2015)) core principles are: '*Dooocracy*'. We value and listen to those who make OSM amazing, whether it be through coding or mapping. We iterate towards excellence rather than spending years in planning. Actions speak louder than words" and "the software running the core of OSM is open-source". These two

principles have enabled an environment where editors for adding and transforming OSM data are available in many natural languages, created for differing platforms. The OpenStreetMap Foundation as a legal entity enables access to OSM data and some core services used to ensure the provision of this data and helps facilitate the ecosystem of applications, but it does not directly create or maintain the software or data; this is done by the OSM community and its contributors.

This reinforces the concept of **communities of practice**, as the community in Tandale, demonstrated in section 5.4 directly through using OSM, interacts with this wider global community. Haklay (2013b) describe this phenomenon of different communities, each empowered and collaborating together, albeit with differing competencies *"... shows the need for technical intermediaries who will facilitate the process, while showing full commitment to inclusion and empowerment of the people who they work with"*. This also adds credibility to the distinction of *catalysts* as a separate role in community mapping.

In the case of the local community in Tandale, 20 community members participated, a small number compared to the official statistics placing the population of Tandale at well over 55,000 residents. Though community forums, demonstrated in section 5.4.2.2 the praxis and maps of community mapping were presented back to the community for feedback. This demonstrates that even though small numbers of community members participate, the map they create can be **trusted** as an output of the community.

Ekdale (2014) presents the relationship between community journalists and the community they serve in Kibera, the community journalists part of the Map Kibera Trust, a **community of practice** based in Kibera, that evolved from the community mapping described by Hagen (2011). This relationship is not an easy one, fraught with mistrust *"I wish they knew that we are doing this for them"*. This is exacerbated by content generated by community journalists being solely online, *"highlighting disparity between residents"*. Here ensuring full enfranchisement is paramount to engage and push towards the higher levels of the participatory ladder, not just within the community, but within other stakeholders also, such as government.

## 7.4 Towards SDI

Groot and McLaughlin (2000) define a Spatial Data Infrastructure as being '*"the networked geospatial databases and data handling facilities, the complex of institutional, organisational, technological, human and economic resources...facilitating the sharing, access to, and responsible for the use of geospatial data and an affordable cost for a specific application domain or enterprise*. Effectively, they are another interpretation of a geographic socio-technical system.

SDIs have evolved as part of a drive to facilitate the sharing and usage of spatial data this is iden-

tified as a key part of the global digital economy; United States have a National SDI (NSDI) policy derived from an executive order from President Bill Clinton -Clinton (1994). Within the European Union the SDI is mandated by the INSPIRE directive - European Commission (2007) - designed to standardise data structures and facilitate data interoperability between European nations.

Coleman and McLaughlin (1997) overview the history and development of National SDIs, linking them to the development and ubiquity of computing, especially the development of the Internet and ability of computing. They provide analysis of the early development of SDIs and NSDIs in particular setting principles for the development of NSDIs; Specifically, they should be widely available, easy to use, flexible and act as a foundation for other activities. They also present the concepts which constitute an SDI:

**Sources of spatial data** : The groups and individuals acquiring, creating, and managing spatial data and databases in the private sector and at all levels of government;

**Databases and metadata** Sets of organised spatial data and information about those sets (e.g., directories), such as where it is located, how it was collected and is maintained, by whom, how it can be accessed, and what the characteristics are (e.g., scale, coverage).

**Data Network:** The communication highways in various forms (e.g., telephone lines, local area networks, and new broadband integrated services networks or B-ISDNs) linking databases, sources, and users.

**Technology:** The data conduits, but also the intelligent connections at each end, optimising the management of the databases at the source and maximising the potential application of the data by the user.

**Institutional Arrangement:** The coordination of the many organisations involved in the NSDI development and maintenance.

**Policies and standards:** The data communication rules, common conventions, and protocols, in addition to the broader and very critical policies addressing social and economic issues such as privacy and pricing.

**Users:** The data communication rules, common conventions, and protocols, in addition to the broader and very critical policies addressing social and economic issues such as privacy and pricing.

The SDI is composed not just of these factors and systems but also encapsulates the interactions between systems; in effect an SDI delineates this system of systems. This list are not the only constraints on an SDI with Masser (2005) noting that *"SDIs cannot be realised without coordinated action on the part of governments*. Williamson (2003) makes a further case for the importance of SDI in the concept of the *"Triple Bottom Line"* namely the Economic, Social and Environmental components.

Because of these definitions and how SDIs are used currently throughout the world, they

broadly are organised with a top down hierarchy with directives and oversight. Within this stack, the spatial data is generally collected/shared by an National Mapping Agencies (NMA). By their very nature these NMAs collect data based on specific legislation; be it topological, thematic or cadastral. The process of data collection, regardless of its actual process and methodology will go through quality assurance and various processing stages to the point where it is released with an effective stamp of quality from the issuing NMA. This data would then feed into the SDI, be it at a national, international or more local level.

The direction of research is moving towards a more dynamic model for SDIs with Köbben et al. (2010) describing the *'SDILight'* concept as a way of teaching and exploring the theory and practice of SDI. They note that a SDI usually "denotes large, complex systems... it is of particular interest to our students that come from developing countries". This is particularly important to students coming from IDCs (most without an National Spatial Data Infrastructure policy framework and potentially a National Mapping Agency (Masser (2005)).

Continuing within this thread in setting a research agenda the nature of map data (thematic, cadastral and topographic) would need to be considered. While the factors of spatial quality have already been discussed there is currently no literature linking spatial quality with the practice of surveying VGI data.

Within this, the assumption that the data within SDI is from an authoritative source is made. The top down nature of SDI jars against the bottom up nature of VGI. What are the requirements of countries which may not have legislation and policy around SDI and NMAs? What factors need to be considered to make the data created from crowdsourced mapping authoritative? What is the relationship between authoritative and quality. Is 'good quality' equivalent to 'authoritativeness'?

## 7.5 Chapter Summary

This chapter finalises the discussion of the concepts and empirical work that this thesis has undertaken. The proceeding chapter concludes this thesis.

# Chapter 8

# Conclusion

## 8.1 Chapter Introduction

This thesis examined community mapping and how it can and is starting to address the lack of data in developing countries. This chapter concludes the thesis, examining the research questions, aims and objectives and how they were achieved. Further it discusses the limitations of this research, sets a future research agenda and closes this thesis.

## 8.2 Meeting the Research Questions, Aims and Objectives

Chapter 1 introduced the research questions, aims and objectives of investigating community mapping in Industrially Developing Countries (IDCs). This necessitated an approach to first examine, then to demarcate the design space of community mapping, from which new tools can be designed. The concepts raised were then distilled into a conceptual framework. The following subsections examine how the research questions, aims and objectives were met in the context of this research.

### 8.2.1 Community Mapping: Bridging the Data Gap

The maps of many countries around the world are either blank or present sparse, out of date information: presenting massive challenges to institutions such as governments or development agencies in terms of development and the provision of public services. By examining community mapping case studies in sections 5.4 and 6.3, the characteristics of community mapping were elicited providing insights into the praxis, roles, functions and situations of community mapping in IDCs.

By assessing the quality of VGI produced by the community mapping process in section 4.3, it was demonstrated that community mapping presents a richness of data that is unheralded in the IDC space, and was demonstrably of a higher quality than the authoritative reference dataset. This proved the potential of community mapping to bridge the data gap in IDCs. Additionally, though others have suggested that comparing authoritative data and VGI in IDCs previously, this seems to be the first study to do this due to a unique combination of reference and VGI in an IDC.

Through grounding the approach to community mapping, the role of the catalyser was identified, demonstrating that full citizen control (a key component of achieving citizen and community participation) can be achieved in community mapping; that the inception of a coalition of international and local governmental, parastatial and non-governmental organisations can transfer and empower communities to take control of community mapping as an extension to just participating.

In examining the process of community mapping and specifically the social interactions and community processes it is argued that community mapping can be authoritative, due to the fact of its creation from community knowledge (section 7.2.5). Data has since been used by local authorities as baseline data to aid in the response to a cholera outbreak. Though the efficacy of this is not fully understood, it indicates the significance and impact of VGI and the community mapping method in Tanzania. The emergent understanding generated through the investigations of these case studies generated objectives for the definition of a formative socio-technical design of community mapping.

### 8.2.2 A Formative Design of Community Mapping

By identifying the roles, situations and functions of community mapping, a design space for tools to utilise community mapping was generated through a Cognitive Work Analysis (CWA) in section 6.4. The CWA showed the form of community mapping as a complex socio-technical system, illustrated in what situations community members could participate in supporting the work domain of community mapping.

In identifying formative design of community mapping the definition of constraints of community mapping in section 6.5.1, provides guidelines and recommendations for future implementations and iterations of community mapping in IDCs. This allows community mapping participants to finish the design 6.5.2: enabling community mappers to make their own decisions in mapping their community, using the tools and approach they deem most suitable.

This differs from normative methods of collecting authoritative reference data, the traditional approach taken in National Mapping Agencies. This approach allows a richness of VGI for IDCs to be collected, allowing communities to collect data most relevant to them. It is argued

that this could potentially identify challenges and causes for the lack of public service provision in their community.

### 8.2.3 A Conceptual Framework of Community Mapping

The development, deployment and investigations of Ramani Tandale in sections 5.4 and 6.3 led to the distillation of a conceptual framework for community mapping in Chapter 7. This is built directly from interviews with community mappers and primary observation contrasting with other frameworks created from secondary evidence.

The creation of this framework enables the answering of this thesis' research question: What the characteristics of community mapping in developing countries.

## 8.3 Suggested Further Research

This research has illuminated the emergent phenomenon of community mapping in IDCs. Due to the emergent nature of the field and the overarching emergence of VGI generally, there are many avenues with which to continue research and new potential research directions to consider, offering exciting potential.

### 8.3.1 Continued Engagement

Chapter 7 discussed briefly how the scaling of community mapping in Dar es Salaam has occurred through the Ramani Huria project. This occurred as a direct effect of the Ramani Tandale project discussed in Chapters 5 and 6. This was instigated by the Government of Tanzania, supported by the World Bank and the Red Cross. It breaks new ground in Sub Saharan Africa, moving away from the Ramani Tandale and Map Kibera model of engaging in a relatively small geographic and administrative area, to covering a city. One direction would be to understand the efficacy of this thesis' conceptual framework to scale and whether new factors emerge.

VGI generated by community mapping has been used to identify at-risk areas, mirroring the usage of geographic information first demonstrated by John Snow during the London cholera outbreak of 1854[1]. However, the full impact of VGI in this context has not been assessed nor has the method by which government institutions like the Dar es Salaam Municipal Council

[1] An interview conducted by the author, while in a non-research role, https://markiliffe.wordpress.com/2015/09/10/data-driven-governance, video released as open data, CC-BY-SA 4.0

are using the data been examined. Continuing research along these lines offers the opportunity to critically demonstrate the impact of community mapping in improving the livelihoods of communities in IDCs and presents pathways to understanding how governments can engage and use VGI.

In this approach, opportunities exist to explore the social space of community mapping in deprived environments in IDCs, potentially contrasting with more affluent areas in IDCs. This would contrast with Haklay (2010b) findings in IACs where a bias exists in VGI for socio-economically deprived areas.

In terms of VGI, as data now exists and is freely available, there is the potential to perform and extend insights into intrinsic quality analysis along the lines and methodologies of Barron et al. (2013). In other IDCs if community mapping and reference datasets are available, then comparative quality analysis could also be applied thoroughly, as opposed to partially as covered in subsection 4.3.5.

In this scaling of community mapping, opportunities exist to examine the limitations of CWA, amplified when considering Moore's Law of technology. Instances where drones and street view cameras have been used to support community mapping are now in play[2]. New physical objects and priorities can be added, but how will the scaling of community mapping present new constraints? This in turn would have implications for the development of VGS in practice and theory, moving away from innovation pilots to embedded, accepted public use.

### 8.3.2 New Directions

As discussed in section 7.4, VGI in IDCs and its use by government as a primary dataset would be a new direction. This would help bridge certain institutional challenges in Tanzania, with respect to the sharing and dissemination of data - a stated need of the government - but would also inform how 'lightweightâĂŹ Spatial Data Infrastructure (SDI) programmes can be implemented in IDCs. The proposal for lightweight SDI, in keeping with the formative CWA, could complement and support existing governance and policy frameworks such as the many Open Data programmes occurring in IDCs (in part due to the challenge of data access), as opposed to replicating institutions found in IACs. This offers the opportunity to generate new theories of VGI and SDI engagement in IDCs, as opposed to ethnocentrically applying IACs SDI models.

Smart phones in IDCs have become ubiquitous, enabling access to new forms of public services such as those supporting people who previously were disenfranchised by formal financial systems, but now have access to mobile financial services, such as mobile money. These do not

[2]For example, see *http://elpais.com/elpais/2017/02/21/planeta_futuro/1487690686_222911.html* for how drones are supporting community mapping in Zanzibar

conform to traditional systems and theory, exemplified by the formal banking sectors requiring knowledge of their customer's location and assets prior to the authorisation of loans. New paradigms such as mobile money lock financial services to the mobile phone and use metadata to assess customer factors such as monthly spend, average wallet amount in credit scoring. In the VGI context the metadata is the key factor. This metadata contains location information and so with enough transactions spatio-temporal insights of people and communities can be built. These insights could uncover mobility patterns that inform on more appropriate urban planning strategies or demonstrate placement of public services based on public need.

If such spatio-temporal insights could be generated, opportunities exist to examine how novel data streams, passively sourced could contribute to creating maps in IDCs. Blank spaces on maps where deprived, informal areas exist in IDCs are still common. Thus in keeping with Goodchild (2007) - *"citizens as sensors"*, can through passive use of data, lead to the creation of maps that fill this gap, leveraging the now ubiquitous sensor of the mobile phone? If so, then to what extent can historical data assess how areas in IDCs grow and evolve or to what extent can their growth be predicted?

Additionally, the role of new tools in supporting communities becomes relevant. At the time of Ramani Tandale, tools such as Humanitarian OpenStreetMap Team's Tasking Manager did not exist, now it exists in a toolset, used by projects such as Missing Maps. The developments in the availability of imagery and a widening of global participation, again through projects like Missing Maps presents an opportunity for faster mapping, enabling community mappers to focus efforts on collecting data relevant to them.

## 8.4 Final Conclusions

The conclusion of this thesis is that community created VGI can bridge the data gap in IDCs, offering the potential of a freely available, open dataset for government, whose richness is unmatched by local authoritative sources.

Arguably, this is the first study of VGI of this depth in IDCs both in the Geographic and Ergonomic research domains. Demonstrably, this thesis is very timely due to subsequent research in community mapping by Haklay et al. (2014); Soden et al. (2014); Soden and Palen (2014); Crowley (2014); Forni et al. (2014); Palen et al. (2015) and others. Through engaging directly in IDCs, this has provided an opportunity to generate new theories and concepts of VGI while reframing traditional geospatial concerns such as authority and quality.

While VGI and Neogeography are relatively new, emergent fields the impact that they can have on the world is great and potentially could be larger as they become an established technique. Due to the commitment shown to community mapping by institutions such as the

World Bank, Red Cross and National Governments, local and international communities are engaged. This enables citizen power to be exerted by those who live in informal, deprived settlements, strengthening community control of mapping. This is the ultimate aim, not to counter these institutions but to work together, generating new maps and removing the hidden spaces from our world.

# Appendices

# Appendix A

# Participant Interviews

## A.1 Chapter 5 Interview Transcripts

The following interview transcripts took place in support of the case study of section 5.4. Table A.1 identifies the type of mapper responding, either a student and/or community member.

| Mapper ID | Classification |
|---|---|
| Catalyser 4 | Student + Community Member |
| Mapper 5 | Community Member |
| Mapper 6 | Student |
| Mapper 7 | Student |

Table A.1: Mapper Classification

### Catalyser 1

*What is your role?*

My role was a trainer of trainees, training youth and community members in skills I acquired in Kenya. In Kenya I am a mapper, the skills I have are how to use the GPS for collecting data, tracks, and on software for the work to be uploaded. Four software:

1. JOSM
2. Java
3. GPS Babel - To pull data from the Garmin GPS

4. Garmin Drivers

Worked with UNICEF to map Water, Education, Health and Security; thematic mapping for Kibera through Map Kibera. When Map Kibera started we were trained for three weeks, then everything was at a standstill. But with passion it continued. It is now a trust. There is now Voice of Kibera. We found with the map itself there is a need for the map to be used to fix issues by the community.

KNN - The Kibera News Network allows for posting of blogs and videos online. Ushahidi is normally for crisis events. People air the things that happen. They report stories. They have a [SMS short]code which they use to report. Via online we use cameras and videos, also through mobile phones send via SMS.

*Important Issues*

Involve the community. They know the issues that affect them, ie. where the hospitals are [informal and formal]. Opportunities for better planning of eg budget participation.

Challenge of mobilising the community. Problem of funds. How can unemployed people participate? Issues is that they are the target. Solution is to give stipends, also local government is a concern for involvement.

*Data Collection Issues*

Lack of skills, need skills for use of computers. Build the fundamentals first. In Kenya we did not involve the community, but in Tandale it was community-led. Everyone had an opportunity. In Kenya we did not involve the government. Tandale we did. By involving them from the start they can be able to have an idea of the needs of the community.

*What have you learnt?*

For you to achieve your objective, when you start something, you need to share with the rest of the community. When you train a community, especially one which at first isn't well informed, you should at least be neutral. Don't sideline or divide people and say they are not good. They could have the drive to learn more.

## Organiser 2

*What is your role?*

World Bank ICT. Support urban colleagues in Tanzania, specifically with a view to gathering information and strengthening capacity in local government for improving capacity for infrastructure and planning. Task Team Leader/Project Manager for WB involvement in Tandale.

Request from Ardhi University to allow students to make better use of their industrial placement, giving better skills and to apply those skills to directly to projects. Urban planning specialists with local government on understanding informal settlements and upgrading local services.

An opportunity to pilot new methodologies, tools and techniques in spatial data capture, generating fata with communities going towards a more open and sustainable model where low cost or free tools are leveraged with community participation to generate a lot of the gaps that official information structures have.

My role was to put together this collaboration, deliberately doing things a bit differently. We worked closely with Twaweza, and they drove a lot of the engagement, equipment and training with a good on-the-ground presence in East Africa.

We worked with Map Kibera, who have real heritage in this methodology. Worked with local government to engage with their needs ensuring it really addresses their needs for urban planning, to create a dialog around urban service needs; A multi-stakeholder effort.

*Important Issues*

Especially in unplanned areas they [the citizens] know what their problems are, but they lack the voice and quantitative message to get that message out. The unplanned areas are growing very quickly, 3rd fastest in Africa. The unplanned neighbourhoods where the greatest service needs arise, community members know their problems. If they have a mechanism to capture and disseminate it, that's what we're here to address.

Typical needs were around sanitation, toilets, waste, rubbish, health, water bodies, malarial, confluence of water access and sanitation points/solid waste collection, security, lighting, business supply chains; these were things we mapped and had a conversation around.

*What Services Can Be Improved?*

Very broad, depends on the stakeholder/multi-stakeholder effort, local government initiative together in partnership with universities. A lot of niche applications and mainstream ones, the big is the planning of that the local government will put into consultation around the planning process. We now know the number of persons per waterpoint/toilet, streets - begin to discuss what gets upgraded. Lights are a prioritization process for local government. Think about grievance addressal - if a trash unit isn't collected, how can they tell us?

Map is interactive they can come and tell us "giant pothole; the street lights haven't been put in; the trash hasn't been collected, needs feedback to supervise the implementation process as well as address the needs in a timelier and efficient manner".

*What Problems Exist?*

Unplanned communities are challenging by their nature, very few services including access to electricity, internet. Advantages of OSM are data is in the public domain, requires internet access. We built the project with the premise that there are a wealth of low cost tools that community members can now easily adapt and employ i.e. their own phones. Also internet access costs have dropped considerably. Internet access was provided at the ward office with 3G dongles + laptops. This was helpful as even though there frequent power cuts, batteries ensured you could still upload and download. Still a slight barrier to entry.

Most citizens of unplanned areas will not have easy access to the internet or mice and keyboards - they are familiar with the phone. Range of tools each with advantages and disadvantages, the overall promise is that the costs and usability are changing dramatically in this space. Today access to phones in an urban unplanned community isn't a problem - internet is coming faster and faster. We hope in a few years time local government will be fully connected.

*What steps need to happen to integrate this with SDI + Local/National Government?*

Merger between formal and informal geospatial data; you have an authoritative dataset from the government which sometimes is out-of-date, at times very precise, at times hard to access. We have the challenge of access to information. Transparency of information - sometimes it exists but isn't public domain. So citizens cannot look at it, sometimes it isn't accurate and would benefit from validation/updating from community members. The key is to get those numbers of society who know best the problem to communicate that information to those organise that information and then share it. We see lightweight SDI as a key growth area for developing countries to facilitate the participation - social dimension of the mapping process. Making free and open source web-based tools for sharing maps, editing of maps, publishing of maps that makes life easier, they're free, usability is better. They convert them from format to format, they update more, publish to large communities that can help.

Look to engage the formal information infrastructure of a country to a broad based community of professionals that are interested in the participation side. Participation is huge; allows us to update, improve, validate and spread the message.

## Organiser 3

*What is your role?*

I came to broker a relationship between two communities; one in the OSM community. I had been part of it in Nairobi for the Map Kibera project and the operational side of the World Bank, which is interesting in revitalising urban infrastructure (roads, streets, drainage, waterpoints, solid waste collection) so we started a conversation about how to use this methodology to deliver public good to residents of Dar Es Salaam.

*What is your job?*

My job was to bring these partnerships together and put together the program and timeline for how this will be implemented, ensuring it is tied to the public good.

*Aims of the project?*

This was prep for the Dar Metropolitan Development Project; an investment the WB is making with the city council. The goal was to prepare geospatial information for it's implementation and to create a network for the public good.

Ties to a big picture goals for the city of Dar Es Salaam. First is the identification and creation of high quality geospatial data at the community level. Open Data as a movement largely at a national level and is generally macroeconomic data. How do you generate information relevant to communities?

Second. How do you create a network that is active and can be utilised in partnerships with partnerships going forward?

Since the local government is dependent on revenue from the national government they often overlook their relationship with residents. So if you have a common tool, in this case OpenStreetMap, for residents in particular youth who are interested in these skills and they city who generally have different goals OSM is a way for them to create a platform to engage together on these issues.

To add another level on the urban policy perspective, this aids two goals:

- Transparency - Residents having access to information about ownership where different infrastructure are.
- Revenue Generation - To help city bodies become more independent or more dependent own citizens in delivering better services.

*What Issues Exist?*

Long way to go to operationalise community mapping, a lot of bodies are not comfortable with how this tool can benefit them. A lot of barriers to the notion that this information can live in the public domain. So what does that look like when you further engage the public?

## Catalyser 4 - Student and Community Member

*What was your role and your skills?*

I was a facilitator for students and community in how to make a good map. I was a role model they see a youth like me it is a key role. Skills of collecting data, uploading data, how to

communicate to the community a little bit of GIS knowledge, good mobilizer, facilitating, monitoring and evaluating.

*Aims of the project?*

The aim was for the community to be highlighted how the maps can solve their own problems. The moment we went to the map there, the community showed us the point of interest, we showed them how to map the point of interest. How to use the map to solve the problems they have in the community.

The process I was facilitating was the first time the community and students were mapping. The students had knowledge, but I wanted the community to learn the methodology. That's why I was so interested on the first day to show the community the GPS, how it can be configured to collect data, we go to a computer lab to upload the data for it to be seen on OpenStreetMap.

On the second day I dedicated a community member to handle the GPS and I showed them how to collect the coordinates, the points. The member was willing to learn. I showed them once they rested, they did it accurately. After collecting the points, I showed him how to upload to the computer, until the last day we had the map.

*What Issues Exist?*

A problem that can be highlighted is the drainage system. Themselves they complain about drains and floods. There is a section where the house is gone completely, the community needed to be resettled elsewhere. The houses are not in a planned way, it's an informal settlement. A lot of dead ended roads where people build houses in the middle. The health, I saw compared to Kibera, health facilities are few compared to Kenya.

*What is your experience?*

In Kibera we needed mapping for health. In Tandale there are two health facilities, if there is a pharmacy, it is far. If someone is sick before taking them to healthcare, you take them to buy medication from the chemist; you go to the roadside, but inside the villages it is hard.

*What services can be improved with this map?*

A map can help solve issues. For example with health, if that map is given to someone, they will see a need and do something. The people themselves own the data. Sharing it allows more to see the solution. They should [the community] take the initiative and go to the health authorities with the map and demand things to be done. I believe it; the change is there. The communities themselves working hand in hand with the authorities. Tandale was done with the local government, in Kenya the Nairobi City Council was not involved.

CCI help us mobilise the community, Twaweza helped with equipment with the World Bank and GroundTruth.

*What Problems Exist with the Methodology?*

The problems in Tandale, the community wanted to do things without the students. When I was there, if I left a computer with a student, they would complain. They want to do things themselves, it was a positive thing, they wanted to lead. It took time for them to learn though.

They wanted SMS for Ushahidi, but it didn't work to the map. The other components like SMS could work, but you need the map. Ushahidi and a blog can help report. The voice can be a voice for the community platform to highlight problems that occur. It is a community voice as the community themselves are reporting through the platform 'speaking through the platform'. No one person is listening, it is online, go there, you see it.

*Comparison of Ramani Tandale and Map Kibera*

My experience is that they are friendlier in Tandale. In Nairobi we didn't involve the City Council, but here government officials were there and interested and that is a big plus. This is a good thing as all stakeholders where there; students, community, government, local NGOs, international NGOs, to make the map and bring it together.

*How does the integration with the local government work?*

The ward and subward officers where there, the City Council and Mayor was there, as was the ward manager, a Big Man, the expert of the ward of Tandale. Other stakeholders were there too.

*What lessons did you learn as part of your exchange?*

When I go back to Kenya, when I do this again I must involve all stakeholders, for it has to be successful, working hand in hand. If I make a map and I go, no-one will use it. You make a map, involve the community and appoint it to those responsible for resolving those issues.

## Community Mapper 5 - Community Member

*What is your role?*

In Tandale first of all as you know we were created in four groups. Me I participated as a mapper in a group of mapping. My big role was to go out in the field to collect the information at the field through the use of the GPS. That operation you could the details about the shops which are around there. About the infrastructure. Sometimes with the sanitation on there. The market. The schools. Each necessary feature. Some feature you can use a symbol in the

mapping. That means heights the information. Then after we go back to our meeting place. We lead the way to the editing room. Then they continue with the editing. Apart from being in the mapping group it doesn't mean I'm only relying on the mapping.

Sometimes I used to edit some collected data. We used to alter. Apart from that I had to trace a building. I trace several buildings and some dump places. I upload some information about Tandale in our group. If you go there you'll find my comments. I teach my community how to use the GPS. How to upload. How to open the accounts. There's a lot. Apart from that, I discovered issues about Tandale. I'm the one who discovered several issues with sanitation. Things about poor infrastructure. The issue about poor housing condition in Tandale. Issue about water. Water is a big problem in Tandale. Several issues I discovered over there. I wrote a report about it. That's what I can say about how I participated in Tandale.

What I can say about this project. This project is very good. First of all, it involves the indigenous people. The people over there, there are the one who are the key stakeholders of the project. That means that the project will be most sustainable for the people they know much about the project. If you can really change the project, the people can ...

What I can say about that ... Apart from that about the project I can say that I was more ... I would feel more comfortable about the equipment which we used. The equipment were very modern one. When we go to the field ... Once you as you go there the white pads were already recording tasks. When you go back to the meeting place you will just need to connect the ... Apart from the ... something which is very good more than ... It was very good. I was very comfortable in doing it. It's quite different from our own.

*What was your personal contribution?*

First of all the moment we ... Not be able to know about the project. We are the one who told them about the issue. Apart from that the features which we collect over there wouldn't be available. Even the first going of the project will be spend a little time, but we will come up with the big output. The project maybe may ... It might be delayed. There is maybe without me.

*What Services Can Be Improved?*

First I will say about the provision; water provision. Then improve the water. They are already there. What's needed is money. Some issue about the issue of monitoring and the issue of, how can I say? Apart from water provision we can talk of improving sanitation of Tandale. How are we going to improve the sanitation? We already know where the problem is. It's all about coming together all the stakeholders. Deciding what to do. This means the community should be able to be key stakeholders. If we can go there. We can give money. We can go there do something.

*What Problems Exist with the Methodology?*

For the project to be more sustainable. For the sustainability of the project community members should be involved fully.

From my point what I can say. If and only if you want your project to go first through few people. First of all, you should hear some people's knowledge about that. As you can see you started from Kibera. When you came over here in Tanzania we came with 'ĂIJthe catalysers'ĂİĂİ . They are the ones who taught us about the project. The students should be involved so that they can be attached to the community members or they can teach them how to conduct the project in general.

*You think students should always be involved within the project?*

Yeah

Do you think the community members themselves need more proficiency with technology to get to the same level as the students? That's can be possible, but not really. You must have some guys who already know. In the beginning you should involve, then after the when we the community can take over.

## Community Mapper 6 - Student

*What is your role?*

In Tandale Mapping Project, I was involved as a student from Ardhi University. It was part of our learning. It was time for industrial training. We joined into the Project to assist the community members of Tandale in Mapping their area. At the first time when we entered into Tandale we found the community members. They know nothing maps about their area. There was a problem in their area. Currently they didn't know really what the problem.

We started the Project with GroundTruth Initiative where they were facilitating us. They were giving us the information on how to do it. We learnt slowly. At the end of it we managed to help the Tandale community members to map their area. I as a student I was just helping the community members on how to use the GPS. To use the computer. To collect the data. Also I was their translator, because others they didn't know English. I made them to get the information.

*How do you think what you did helped the Project? How do you think people almost translated facts when they needed to speak English to other members of the group including myself?*

Sometimes language used to be as barrier. If you can't communicate with them. They don't what you intentionally want to tell them. It is very difficult to understand each other. I as a

translator, I facilitated them to know what you were trying to tell them. To teach them about the Project. They managed to get that information easily. They understand it easily in local language. I mean Kiswahili.

*What was the role of technology from your perspective in both yourself understanding, and learning how to use the GPS? Was that your first time using a GPS?*

No, we at our University, we as the planners we use to work with tools such as GPS in picking the corners on... making preparation for land use, preparation for neighbourhoods. We used to pick the points so that to know exactly where the place is on the earth. So, it was not my first time to use GPS at Tandale Mapping Project. It was the procedure. The kind of GPS which we were using before is local [old] one. The GPS which used in Tandale Mapping Project it was the modern one.

The former [old] it used not to show the path. You just switch on and then you pick them as a point not as a path, not as a way. It is upon you to go and and trace it again. So, by the GPS which we used at Tandale Mapping Project it's different, it's just helping you even to trace where you've passed. It's a little bit few editing of the path. The technology played a big part in mapping project. I mean that's what it is.

*How do you think that translated across to other community members and student?*

For the community members, for the first time it was difficult. They didn't know even what GPS is. As far as we students together with the other people. Having [names redacted] [they] assisted them to know first, "ĂIJThis is the GPS you can switch it on. How you can pick the points". They were just learning slowly. At the end they come up and they manage to use the GPS. Not all the community members at Tandale they can use the GPS. Only those few ones who we get in the Project. They are the ones who can use the GPS.

*What was the most important issues addressed in Community Mapping?*

The important things which we found at Tandale they didn't have ... The collection points for their waste. There was an issue of poor waste management. They used to just throw the garbage on the drainage channels. Another thing that they don't have ... The water points are very close to their toilets. Sometimes as we know the toilets are very near to water kiosks where they used to sell the water. You might find that there is a problem on other sub wards or streets. You might find that they have got the problem of water. Their drainages are totally blocked. There is issue of drainage channels.

They used to pump water to the tank and then from the underground, they used to pump the underground water to the tank, having nearby toilets and then you pump water and when you sell it. That water is not safe and clean one for drinking and you can do that. It really doesn't have, I mean, the water channel from Dawasco, the [water] authority of Dar es Salaam, which

is authorised to supply water, they don't have the connection. That's why people they are forced to used the underground water which is not safe.

*What services can be improved with this map?* We can improve the registration, maybe by allocating those or specifying the specific areas for Dawasco because Dawasco are the ones which are providing water, they used to treat water from their tanks at Ruvu [River]. We can negotiate with them, that in Tandale they don't have water and people there are really need water. They can't continue using the dirty water which they are just pumping from the wells. So, they can have a new design for the area, for distributing water from Dawasco, because they were distributing, but because they see people vandalising the pipes, but they can they just vandalize those pipes. They sold them. Them but they can redesign it and then the people there can have clean and safe water.

*What Problems Exist with the Methodology?*

For the time I was working in Tandale Community Mapping Project, I didn't see that there was a problem such that to call it a problem. There were some few challenges, just challenges but not the problem.

One of the challenge which we faced at the first time is that the security issues on those streets, there are a lot of robbers at Mtogole, so we were going there but fearing that maybe they might steal our phones, they might steal even the GPS. We thank God they didn't do that, but they were chasing us but as far as we were walking with their men.

We were walking with their leaders, others in the group they were leaders of their streets. They were just protecting us, that was one of the challenge.

*How challenging was the environment of Tandale?*

With the environment I didn't see as if it was a challenge because we are used to seeing most of the areas in Dar es Salaam are informal so we have the experience of seeing those kind of settlements so it wasn't just like challenge. It was okay.

*Do you have anything else to say?*

What I can say is that the Tandale Community Mapping Project was a really nice one project I've ever participated before. If it would be expanded to other areas, I mean the informal ones, because the formal ones they don't have much challenges compared to informal settlements. It will be easy and it was a very easy way to make the community members expound or explain their problem and see it, it's just really big problem. You might find that people have got problem but how to tell the leaders to assist them with such problems it's difficult. What I can see in Tandale what we did, it was easy even if we will take the map and you take it to the city council or somewhere else, it is easy to tell people in Tandale there is this problem

and they can understand you. The real problem it's on ground and the community members themselves are the ones who identify that it's an issue. Yeah, that's what I can say. It will be better to expand it into other areas.

Other people coming into the project, it wasn't a problem or it wasn't an issue. It was good as we knew that they knew something and they [were] going to teach us what they know so we can improve areas. By having the other members assisting us, it was really a good idea, we enjoyed and understood what they taught us. At the end, we came up with the good map, a speaking map, which speaks for itself.

## Community Mapper 7

*What is your role?*

I am a student from Ardhi University. We're given the chance to come to the program. My big role in the project was tech support and teach. And then to transfer the knowledge of me to the community. To teach how the computers, how GPS works, how to use the internet, open an account on the internet, and all that. That was my big role in the project. By teaching the community how this technology works, it helps the whole team making map.

*What sort of technologies did you use?*

Technologies that means ways in computer in making maps. We went, by using GPS, went to pick data at the sites. After that we came and we load the data into the computer and editing that data through OSM.

In the downloading data from the GPS into the computer, we were using GPS program called GPSBabel. To edit after the downloading data from the GPS to the computer, we were using OSM program, JOSM. After the loading the data, we were using that program to edit tracing the data we had downloaded from the site, and after that we are uploading the data to the internet.

*What was the most important issues addressed in Community Mapping?*

Okay. The thing that we were mapping when we were going out. It was different, we were mapping things in terms of issues that concerned us. This is means that issues like water. We were mapping water facilities like water tanks, tubs, if there are any. Other thing is the road. We were passing through different roads, showing them that this is the road, the attributes and accessibility of the road. The other thing that we were mapping is waste, where the people are just putting the solid waste.

*What services can be improved with this map?*

Now you've got the data, I mean you have the map. It's easy enough to show that each problem ... Where's the problem? Because you can see the map and show where is the location of the water tanks, where is the location of these toilets, we can see in the data. So, it's easy for the solving of the problem, and you can know where to start, easily by using the map.

*How are the community members going to access this information?*

The community, for accessing the data, is after because when you finish the project, we help them with the tools so that they update. I mean, the computers, the GPS and all that, so that it can be easy for them to update. I mean to access the information. Though we produce the map, and we left with the map that we were producing but after going with all the project, one of our output was by the printed map. I presented in the community forum how is the map, so that they can edit and they can confirm that this is, how it is on the ground, and they edited what may be wrong, so that map that we presented to them, were one of the output that we gave them. The other one is the, the tools, the technology, I mean computer and GPS, so it could be easy for them to update if anything change to the program.

*How much work is it, to keep the map updated?*

Because we were already collecting the data, I mean we're having the map already so when changes come, it is easy for the community, and the community knows the places they have to just go and type the point and upload with that. I say it is easy because ... I mean it's easy for those who participated to the project because they were already know the project. I mean the process, and how we're doing because, they're the one who participated in the project, so they knew all this process of using GPS, uploading the data, using the computer, this model.

*What Problems Exist with the Methodology?*

Things go wrong where the community were not catching up with the program. I remember one day, we were from the field and we were uploading, so for the moment I start tracing the data. Others instead of tracing were deleting some of the data, so I supposed to go back and take the point again and pick the process, so that is most of the challenge that we were facing.

*Was it just exclusively the community members?*

No.

*What are the other challenges that you faced?*

I remember the other problem that we're facing is, we're facing with problem of electricity, the power, other times, we're failing. I mean we're failing to go on the normal process because the process is to explain so what's going on that day, and so other ... I mean people could just go to the field, but because of the power were going off, we're failing to use computer so the people were not going on.

*Do you have anything else to say? Do you think it should continue? Do you think there's improvements to the methodology?*

Yeah, this project is good. I mean, it made me know a lot of things. I think because we have the community who knows the process already, so it is easy to take them and so that they can also ... if you teach one, and one teach another, and one teach another so you get many.

*What is the expectations? What do the community members think should happen now? I mean some of them participated; they gave information; how do they stay up to date with what is happening?*

When this project was happening the government was thinking because they now know the places, I mean they know the problems, the road accessibility, and water problems, and they knew that this project is coming from The World Bank, so they were expecting improvement could come in terms of the problem, such road accessibility and all that. That's what they were expecting.

*How do they expect to find out if these improvements are come out? Do they expect to come to you? Do they go to the ward officer? Do they look at the map?*

Because in end days we're having community forum, and they discussed and this ... I mean, those tools were to be left to the ward manager, I mean the ward executive. So, they knew that anything that they wanted to know they were supposed to go to them, to their leaders, to the ward officer so for all the information to go the ward officer.

## A.2 Chapter 6 Interview Transcripts

The following interview transcripts took place in support of the case study of section 6.3. Table A.2 identifies the type of mapper responding, either a student and/or community member.

| **Mapper ID** | **Classification** |
|---|---|
| Mapper 8 | Student |
| Mapper 9 | Student |
| Mapper 10 | Community Member |
| Mapper 11 | Student |
| Mapper 12 | Community Member |
| Mapper 13 s | Community Member |

Table A.2: Mapper Classification - CWA Chapter

## Mapper 8

*Can you explain your role within this project?*

The role of me to participate in this project in collecting the data, to assisting and collecting the data such that because of the output which is in there, by the needs in order to obtain maybe to do an analysis with the data which you are collecting or to propose something, since you are collecting the data, which are concerning the flooding as how initial go to from there preliminary introduction to the data which you are collecting, they are concerning the floods.

So, in collecting the data, my role that it's too much for the particular data which you are collecting, they are relating to the field, to in the field that we mapped. For instance, the data concerning the drainage system or drainage you can find that the drainage which is planned and unplanned but in the area we found that that they've some water channels which are not planned, so they need to be planned. Such that if the water it cannot effect the community around there.

Also, we try to collect, there is some obstacles for instance in the water channels, basically which are created by the community. That is somewhat obstacles, like they are throwing the solid waste, so the solid waste it's one of the obstacles. As your plan by educating or making sure that the community understands it, what's the use of the water channels, such that it can prevent them from being affected, for instance from the diseases or bad water.

My role in this project is to make sure that I'm collecting the right data with the project concerning the flooding in general.

*In community mapping, what do you think are the most important issues to be addressed? You've been mentioning a lot about flooding and water management, what are the important issues need to be addressed?*

First of all, I'll say community as they plan first, use the tool, involve the community such that they participate in this activity. Although flooding since they have their own, they have the users, they know their place, they are familiar with their place, because they have not decided maybe what it takes to take the channel, also plan the channel, so it's difficult.

For this matter, with the community, let's say I can make sure that the community there involved in, and the issues which to be involved in, it's the water channels, the production of the liquid wastes, and also the pathways to allow the access, some of the things which are that should be involved in. Also how the community is managing those things, because they are not supposed to be going and we put there, but they are also supposed to manage it.

Things addressed, that is one of the important issue how they are managing their area, regarding the flooding in general. To come to sense that, Tandale it's unplanned. If it's unplanned,

people are living nearby to the water logged area. So, is that the area convenient for them to live, to live it there? If it is not convenient, so it means that some, they are supposed to be shifted into other areas.

Issues to be addressed in the project, the important one is to first look at all their facilities concerning their water drainage system, the passageways because the community needed access and also the solid waste deposits here or have to be put and also the water. The water is servicing because the water that should not be contaminated with the floods, because in flooding there are some of informal things which it is involved in there, the communities to allow some of the liquid waste to come out during the winds when it floods. We find that they allow maybe some of the liquid waste to flow, which it leads to the election of the diseases. They are all important, it needs to be addressed. What services do you think will be improved now you've got this data? You've been collecting data on pathways where the floods are, where the water drains are, where the culverts are. What could be improved by using this data in your opinion?

First of all, we have to improve the pathway and they have got the challenge that the area, there just is that, that is a lot of congestion with the houses. We have to include the pathways, and these pathways maybe they should do, we are having the side drainage, but in some place you can find that it is difficult to put the drainage with the pathway. So, You can introduce the drainage but on top of them you can put the pathway first that the water will pass through while people are on top of it.

*It's really about improving, using the data you collected you can improve drainage?*

You can improve the drainage, and they also can improve, you can improve some of the area where they stored their solid waste, because it affects also in the water channels where water passes. It makes the water diverge and not necessarily. If the channels are well conserved by them. To improve the water channels, they are constructing well drainage, and they also improved the passage. It was they need the access also, but they are impressive.

In your opinion what problems do you think exist with the community mapping methodology? What problems have you faced, what issues have you encountered, what challenges have you had? What would make it better? The first challenge in involving the community, it is then it is time consuming that's the problem also we are facing because the community think that most of the information we need, they are barely technical so we can observe, but there are some details which they cannot give us direct.

Also the another challenge, the community they see us, us planners especially in Tanzania they try to think that maybe we are negatively approaching them, to the project that such that maybe demolishing the houses. First the challenge of letting obstacle, being asked by community many questions that leads to wastage of time, and also some district maybe do not,

they do not give the information or they do not allow to pass maybe to collect the information which I needed, because they are some of the obstacles which we are facing in the methodology.

*Do you have anything do you want to add?*

Maybe something to add, but I can say generally the project, this project to be efficient and effective since it involved the community and they are the end-user. We are the planners, we needed to involve them in the plan.

What you have in that then need to go one step further to involve the community and planning. As well as the production of the mapping.

Production of the map since that they are the end-users. They also maybe another thing, which is going to be more useful in collecting the data and they producing the output of the map, we need the team. This will go to maybe different technicians or professions like [urban] planners, or go to the environmentalists. They also go to the, such maybe cartographers there. The team needed to work together. It sends the ideas such that it gives, there is any additional way to adding the methodology to be added without conflicting, which are.

You are saying that there is the many people with many different skills, whether it's a community member with a lot of knowledge.

Community member familiar with area, their knowledge it's needed as in any spatial information that it's important in planning. They also as ...

*Then you can share that with cartographer?*

You can share with the cartographer if he or she that are in there expecting in the field. That's important. It's better to work as a team, to share the knowledge, to build the knowledge. Community mapping is about working together, share the ideas.

## Mapper 9

*Can you explain your role in the project?*

In the project. Much more, or basically my role is to collect and mapping what is just really the situation on the ground to make a presentation on the map as you know. But here on the backbone of the community itself, with the cooperation of the community.

*What did you do that helped with the overall aim of the project? What was your personal contribution?*

My personal contribution is basically on the scientifically contributions on the, basically on the principles and awareness on how to representing the information, and on the view of the

community itself, both on how they pursue their problems that they're facing, or on how or what they need to making a solution to their problems, for transferring those ideas into mapping consideration or into mapping standards. That's basically we do.

*How did you do that? How did you transfer that knowledge from the community to the map?*

The basic idea to communicate with the community is to make a simplification symbols to them to make them to understand what are being represented on the map, but bearing in mind that other people may interpret clearer what it may represent on the map, but those symbols which were basically well-known to the community, but not to that which are well-known to the professionals.

*These symbols, are they symbols you created yourself, or were they already on the map?*

No, these symbols were already on the map, but they have been simplified, we have not simplified them much, but they have been simplified.

*What are the important issues that we address in this mapping project in your opinion?*

In my opinion, as we are targeting this area of informal settlements and they have a lot of challenges, but they faced the challenges which have been facing in all which are being done with, this is somewhat. They some noted as physically forming a problem of water logging, floods and some of water-borne diseases. Being eradicate the disease or being serving this issue is the integrate basing on the infrastructure facilities to drain out this water or to channel this waters which are passing through the settlements.

They are using their so-called this natural ways of stone waters. These artificial manmade drainage channels, which have been basically seen the own-based site. Though the sites, the nature of the sites have been seen, it's have some percentage of, 60% as draining which you are in the natural draining channels, so the main task is to improve them.

*Leading on from what you've just said, what services do you think would be improved now the stage where exists?*

Much needs to be emphasized. I've seen the, problem that we are finding within these drainage channels, natural drainage channels, some of the settlers they have dumping in the seas solid waste within that drainage. I have tried to ask a few of the people why are they doing this and what are the consequence of dumping this solid waste within the drainage channels, so that during the rainy season they are having the problem of blockage of this channel. They have broken this water channels to be flowing out, then they cause back follow of water, then it causes floods during.

*Let's say what have been done to reduce this problem of dumping this solid waste within those natural drainage systems. You can say that there is not much pain from the local leaders, but the*

*aims of the community, they have make the task of removing this solid waste along this major draining channels... you've said that there is a lot of problem with the drainage channels. Now you've gone out and collected that data on drainage channels, do you think there is an opportunity to resolve and help alleviate those problems? Do you think this data is useful for that or not?*

The project will be useful due to the case that most of the natural drainage channels, they are in their bad or worst conditions. If they are being improved much more, to mean that those who water during the rainy seasons, storm water will be passing through that to the channel, which are being directed it to, to their main channels, also their settlement.

*With all of this waste that when the floods come in, it just deposits it, it just puts it somewhere around or where does this waste go?*

Talking on the improvement of this solid waste from many channels, it means that those channels, they are the main ways of constructing these facilities. Basically on this channel is draining channel is on the somewhat during the rainy season, it can be used in this open channels or they can be used via this closed channels. If they will be conducting the construction of closed channels, this means that there will be a limit capacity of dumping inside those channels this solid waste materials. In that case those channels would be underneath here, so that those storm water will be passing it through without that problem.

*What problems and challenges have you encountered during the mapping? What could be improved?*

Be improved in mapping? Much more to be improved in mapping, it's reducing that capacity of mapping without considering or without making any into contribution of this community themselves, because when you are doing mapping professionally in the office or everywhere without making consideration or without cooperating with these communities, much of this infrastructure is failing to operate properly.

*Because we are involving the community in this project, is this better?*

It's better for that, that in the means of making this infrastructure to operate in the long sustain, in that it will be sustainable because they will be aware of what is going on and what is there in the system means, and how they'll make it sustainable in solving that problem.

*Is there anything you'd like to add; maybe how did you upload? Did you have any problems when you are uploading?*

No, a little bit because the software which we are using have not come much away with it. We are using much in ArcGIS, this Java OSM [JOSM] upload, I have not much more using it. Though they owe in the basic function, they are all the same, so have not get much more difficulties and much, no, slightly difficult, it's not much.

*Is there anything you'd like to add?*

Adding basing on the community or basing off the project itself?

*Anything you want to say.*

I can say projects like these should not end in this informal settlements, but their awareness which have been put forward in this informal settlements can be put again in this formal settlements and then the priorities themselves, they can talk with this, the huge challenge of organization to minimize or to make the targets, which will reduce number of occurrences of this problem which we are facing to resolve it now.

## Mapper 10

*Could you explain your role in the project?*

The role on this project was just mapping the platted features and mapping on the flooding features, especially drainage areas, water-loading areas, also adding some pathways. Yes.

*What other things did you map?*

Water tanks, water pipe, water logging areas, drainage, pathways, all roads, cravats, bridge, things like that.

*What did you do that helps with all of this? What was your contribution?*

Okay, through using GPS and Sketch map, which they lead to me on the way to go. When I found some features, which I can identify it? I can map it and I download on the map.

*How did you choose those tools? How did you sketch on the map?*

Using Sketch map, I used my red pen with my notebook, noting the name of the features, which I want to add on the Sketch map, and I draw. If it's a drainage, I draw on the map. If it's a culvert, I draw it. If it's a bridge, I draw it. Then after that, I come on the computer adding to the open map.

*What services do you think could be improved now you've got this data?*

Service would be improving on the community area through the information maybe can be identified path routes. Also drainage systems could be put in clear, people could maybe be told or be trained to not throw the solid waste in the drainage in order to let the water path through.

*What problems have you had? What problems do you think exist with how we've been mapping? What challenges have you had?*

On the first thing ... I was completely ... I don't know how to sketch it. But as the time continues going on, getting some help from my colleagues. And you seek help with them it's me cope on mapping and sketching.

*What was the role of the catalyser? How did the catalyser work? How did he help you?*

The catalyser, he help on the things to do on mapping. Also on updating the information. Yes, on the free map so he's strong at directing what to do. Exact place we are to collect the data and water, all should be collected and all should be updated. Yeah.

*Is there anything else you'd like to add? Anything you'd to say?*

The product is good because it identifies, especially on a flood area? It's helped some maybe don't have all ... some information if we want to go to Tandale, it directs exact place where to go. It can help you to arrive at the exact place.

## Mapper:11

*Can you explain your role in the project?*

The main issue is in the mapping of Tandale, and we are collecting data at this time from the matter of this week. We start by, first of all, where we are trained on what we are doing on the site. After that, we go direct to the site. We're collecting data using the GPS and also using our phones for taking pictures for the map of Tandale. We started from the Pakatcha area of collecting the data using the GPSs. We come back to the COSTECH while we could start by editing those data which we are collecting from the site as, of course, they want to bring on their site. Also report based on the data which are not available. We guess on them today for them using the open street map.

*What do you think that you do personally aids with the aims of this project? What have you done personally which has helped with the aim of the project? What do you see the point of mapping? What is the objective of mapping?*

The objective of the map. First of all, we are looking at the which is called result of the flooding on the area on the map and the area of Tandale. The area is very concentrated, and it's not well designed or has infrastructure, and there is not well designed.

*You mentioned about flooding. What are the other important issues that can be addressed in community mapping?*

At that community or for Tandale, first of all, it seems that the people of Tandale, maybe they are unaware of the problem which are facing them. Maybe they used to dump all the waste or

throw their solid waste in the drains without maybe care. The solid waste. Water bottles, the liquids, plastics.

*When you say solid waste, what constitutes solid waste?*

Solid waste. The waste which is generated from their homes. Whether it's the plastic waste or the foodstuffs. All of them. They just discharge it anywhere. Because since there is no specific place where they could discharge to their waste area. Something needed like landfills from the community discharges. There is no landfill in the area, and the area is not well planned. It's a combination. There's not very well planning, and ... It's not very well planned.

*There's no waste management?*

There's no waste management in the area of Tandale.

*What services do you think could be improved using this data that you've been collecting?*

After collecting this data, it means the infrastructures are there should be improved. For example, I was trying to identify new drainage where water can be flow. The water the area can be flow easily. It means the sewer ready system should also be well. Even the sewerage system should be well also designed to insure that the waste water will used there, produced there, should be diverted to specific areas because other areas, there are some of the pipes which carry waste water from other areas. That means that the area should also be connected to the Municipal sewerage system where the water and waste could be discharged and treated.

*What problems have you had, and what problems exist within that community mapping methodology? You've been mapping for the past five days, and a lot of that mapping has been of your won choice. You can use a GPS. You can sketch. Can you take us through actually how you've been mapping, but also what problems you've had?*

I see. I have said that the area is not well planned.

*No, I mean with how you're mapping. How you're mapping the unplanned area.*

The best way?

*What problems have you had? In mapping, what problems have you had?*

In mapping, first of all, the map which we are using has not enough information for the area which we are passing through. First of all, if there would be a special map which called also direct us, it would be also with that you can pass the area is also if you would have the community member, also called also direct us where we call pass

*So the community member is important to help you direct?*

Another is also the demarcation, the boundary of the area. I've said the area is not well planned. We find that the demarcation is there, but not in the same place or in the same boundary there is a house, so there will not be easy for us to if you are just passing to know this is the the boundary of that place there. If you have the person or the community member, it could be also easier for us, too.

*Do you have anything that you'd like to add about what you've been doing? I know it seems strange to actually say this how we've been doing it because you know I was there, but how were you using the GPS? How were you sketching? Do you have anything you'd like to talk about that?*

Maybe as I've said that according to the area. Maybe before go to the site I should also know what I'm going to do at the area. I'm going to do AB and CD. It is very crucial to pass through the things which you are going to do on the site. Also we should also know that the situation of the community, how do they behave, if we are just passing, because the areas differ. All the people, all the community differ, so we should be familiar with the community in which we are going to build.

*Do you have anything else you'd like to say?*

Also maybe after collecting the data, there is the issue of the software which we are dealing with. We should also be familiar with the software also.

## Mapper:12

*Can you explain your role in this project?*

My role in this project was mainly to train the community, to be close to them and help them when they do, they're doing the community mapping. To make them what's how to do it. Knowing GPS, knowing computer, opening them up accounts, or help them to know how to use the internet and so forth.

*Okay. Just expanding on that, do you consider yourself a member of the Tandale community?*

I think I'm considered that because they feel like I'm one of them, so whenever they have something to ask in a day, they call me and ask. If there's an issue in Tandale, if there's something happening in Tandale, they always call me and sometimes I come to see what has happened in Tandale. It doesn't matter where I am, but because I'm so close to them I feel like I'm one of the community.

*You live very close to here, but not here?*

Yeah, very close, yeah

*What do you think that you do aids with the overall aims of this project?*

What I help is ... The community are doing mapping, right, and they face some difficulties, especially on using the technology. Whenever they have that issues, that's why I come in. They call me in, I come to help. Anytime they have questions, what to post, what to do, how to do mapping, my role is to train them and facilitate in them how to do that. Yeah.

*Okay. What is the point of community mapping? Why do community mapping, why should the community be mapping?*

One of them is we need data; we don't have data for the community. Once we do community mapping we have very community issues like the issues that are coming from the community themselves. If you do mapping, you have that alert. The community did that, because the mapping is done by the community. What they map is according to what they think is important, okay. When you have that data, you really feel the issues that are coming from the community themselves. If you have them, that's one. Another thing is that we have the voice of them. I mean we have their voice. If we have the mapping done, we have the community voice. We can really help the issues that are facing in real time.

*Can you just expand a bit on the community voice; what does that actually mean?*

It mean that issues are happening within the community. There are some different issues that we outsiders, we don't know, but the community themselves knows in deeply. If they speak what they are facing within the community, we can easily know deeply what they're facing. If someone has to come and solve the issues, we would solve the real community problems.

*How does the community gain its voice? Who's it talking to?*

Actually, what they're doing is to take it online, so that anybody who can see and want to come and solve the issue will see and come.

*How do they take it online?*

What they do is they use the computer and GPS and the internet to upload the issues.

*Upload into what?*

Okay. We're using three type of uploading. One is blog, just blog, which they explain in depth about the issue. Another thing is Ushahidi. Ushahidi is the one that links with the map, it's blog and mapping. When they upload the issues in Ushahidi, it goes directly to map, so it's easily to be seen, to be linked with the map. Another thing is the map itself. This is done by just mapping. A community take GPS and go to the field, collect some information, special information, then come to the computer lab, load that into the map. The map itself, it is an OpenSteetMap, so it's just open. Everybody can do the mapping in OpenStreetMap.

*What are the most important issues addressed in community mapping?*

There are so many issues, but mainly we have security issues. People have been stolen a lot. If you go to the map, you can see places where it's not secure. Another thing is the solid waste issue. When you go to the map you can see areas with solid waste issues. Another thing is you can see the lack of water. We have a lot of salty water and we don't have safe water for domestic use. You can see how the salty water are close to the toilets and you can see the issues of the toilets; so many toilets and you can see all those issues.

Another issue they have posted you can see there is an issue of school, they don't have school. We have only two schools in Tandale, so if you go to the map you can just see that. The issue of health, we have two hospitals, but if you compare to the whole area of Tandale, you can see that the issue for the community. We have the issue of floods. This is whereby there is a lot of buildings, there's a lot of people who are living in the flood areas. When you use the map, you can see the flooding areas. Interviewer: You've covered a range of issues there. What services do you think will be improved now this data exists? Interviewee: Water is one of the issues. Another thing is flooding issue. If you go to the map you can see how many buildings are within the flood areas, where is the flooding occur, and possibly you can even know where does the flood occurs. If it's to be solved, those are the ... You can use the map to know the areas and so that you can solve the issues.

*In your opinion, what problems exist with the community mapping methodology?*

One of them is ... I think maybe one of them is language, this is just a big one, is the language. The community here doesn't know English, and the methodology itself is using English. The GPS uses English, the phone is using English, the internet itself is just in English and they post things in their local language. That's one of the issues.

Another thing is the Ushahidi thing. When they do mapping, they're always facing the issues on how to use the tags and the issues of doing the Ushahidi thing. Using JOSM and upload it. If there were ways of just clicking and have the thing mapped, it would have been very easy for having a lot of things on the map, but because it's just a long process you need to go to the field, have a GPS, then download the GPS code name, then use Ushahidi to edit, then upload to the OpenSteetMap. It's kind of long process. If there were a short process so that maybe we can post something.

*Okay. I'd really like to just expand a lot on sort of the things you've addressed and a few other questions. First of all, how do you liaise with the mappers and community members? How do you facilitate?*

One is I meet with them every Sunday, so they know that I'm coming in Tandale every Sunday. That's one, okay. If they have issues, big issues that they are facing when they are doing mapping, they always ask me on Sunday. Another thing is, if a community having a question

that needs an answer, in that moment, they always call me. I always talk to them on the phone and explain them how to do things. Another thing is we use Facebook.

## Mapper:13

*What concerns on the quality of the data do you have?*

We don't have good project data. One because of the community guys language barrier. If it was Swahili we would have been having a better good quality of data. You can see even the tagging it's a show but because it has been tagged differently you can see it's kind of different thing. We need to train them well how to do the mapping and tags so that we have exact data that we need. Yeah, I think so.

*You were a participant in the community mapping, you're arguably as a mapper not a community facilitator? What new things and new processes did you try this time?*

New process was to write. I had to write how to ... New process is to do the blogging I think, whereby though the community were doing the writing of the issues and how to do that especially when it says real time issues. That's where they were doing the blogging.

*Did you do any sketching at all on the maps?*

Yeah, we have done sketching. *Could you take me through how you did that?*

In Ushahidi there is a wiki that can help us have the sketches, field sketching. I was using that to get the sketches for the area that I always go to do mapping. I print that and I go with it on the field. The field paper they have the existing situation so I always- *Is it field papers or Ushahidi?*

Field papers which are linked with Ushahidi I think. With the field papers which shows the existing situation, it can be easy to update and sketch what you can see on the ground. Then use that to edit on JOSM before you upload in OpenStreetMap.

*How did that differ from the mapping you've done previously? Did you use field papers and sketch maps before?*

That differs because before we didn't use field papers we just used GPSs, we were depending only on GPSs whereby we were taking point then writing down the attribute of the point. Now, we have used field paper. We used GPS but it was purposely for tracking where we were moving, but doing the real mapping we were using field papers for sketching.

*What sort of data were you collecting using field papers?*

Floods, drainage system, and tracks.

*What's the nature of the community mapper? What tools do you use, are there one tools that you want to use, are there ones that limit you? What were your problems and issues that you faced?*

On the field papers?

*Well, anything.*

Maybe it's because one of the issues is that, we shifted to using field papers and because the community knew about the GPS, we had to, again, train them how to use field papers when sketching before they upload it.

*Previously you updated the GPS with the map but this time you didn't use your GPS and update it with the map. Why was that?*

Well because we were using new method this time, we were using field papers. So because we had field papers which shows where we are and where we are going, I didn't see the importance of putting the map in the GPS because I was using field papers.

*So that was your call?*

Yeah.

*Great. How does Ushahidi help you solve issues in the community? Could you provide an example of the community saying, I have this problem, you're uploading it to Ushahidi and that it's being resolved?*

Currently none between Ushahidi, or blog, or mapping, have been resolved. Ushahidi is good because it's linked with the map of which the blog doesn't link with the map. If you use Ushahidi you can get the linkage between the issues themselves and the map special information, so you can know where is the solid waste blockage, where does the people get stolen. You can link the reports and the map, so if somebody wants to come in and resolve the issues will be easy to know where to go and where to solve.

*Okay, so with the language, you mentioned that was a very serious problem with the community members. Could you just explain a bit more? Sort of, what do you think should be done?*

What I think should be done is maybe to have simple tool that ... You know if you go to the internet there is a lot to read and know what is to be done, but we have simple tool even if it's in English but they can know fewer ways to know this is what should be done. What should be done is to have simple tool that will be used by the community to do the mapping. It does involve so many things like it is now in JOSM.

*Thank you very much for your thoughts*

## A.3 Interview with Municipal Leaders

This transcript is from an interview undertaken at the the Africa Open Data Conference in September 2015, as part of my other duties with the World Bank[1]. This was with Juliana Letara, the Town Planner for Kinondoni Municipality and Osiligi Lossai, the Ward Executive Officer of Tandale. We discussed the recent community mapping, how they are beginning to use the maps and the data and some unexpected outcomes.

**Juliana:** My name is Juliana Letara. I'm the head of department of Urban Planning, Kinondoni Municipal Council.

**Osiligi:** My name is Osiligi Lossai I am the Tandale Ward Executive Officer.

***Mark:*** *What do you both do? How do you plan?*

**Juliana:** To me, what we do at the office, I head the land sector sections which are urban planning, survey, valuation and land management. In order to plan to do urban planning, we need maps. We really need up to date maps. The up to date maps are our tools because through them, we produce base maps which we will help us to identify the different opportunities within the area, also to identify challenges which we have to address within the community.

***Mark:*** *What do you do?*

**Osiligi:** Me, as the Ward Executive Officer, I have a lot of work I'm doing there in Tandale, including to see Tandale in a good way, in a planned way. As the head of the Ward, the main thing I do in the ... to make sure that Tandale is planned is to collaborate with the Department of Planning to see how we can develop Tandale in a new structure, because we need to see Tandale ... Tandale, first of all Tandale is unplanned settlement, the hygiene situation is not good, so we need to set a new plan, a new program, for the new Tandale, because we want to see the drainage, we want to see the new infrastructure ward, we need to see the open spaces.

As myself, I see Tandale is a forgotten place, so we need to do something. We need to have a special attention to develop, or to improve the living standard of people of Tandale.

***Mark:*** *Okay. How are you two related?*

**Juliana:** The two of us are related when it comes to planning, designing, working with the community to address their issues at Tandale. Yeah, when we talk about Tandale we see that it's an unplanned area, it's now not ... it's now having a very poor development, but when you think about it in relation to its closeness to the City Center, the land itself is a very valuable ... it's very valuable land.

[1] Full details here: https://markiliffe.wordpress.com/2015/09/10/data-driven-governance

The value of land is very high, and at present what we are thinking is to do the redevelopment of the whole area, to work with the community, to talk to ... first of all to talk to them, to educate them, and to let them see through the potential of that land, and that if it can be mapped, they will all have a better living standard.

***Mark:*** *Before community mapping, what maps did you have available?*

**Juliana:** Before community mapping we had some basemaps which were made in late '90s and early 2000. They are really outdated, more than 10 years, 15 years ago. To work on those ... to work on those biz maps it's very challenging, because a lot of development happened, and to be able to work ... to use those biz maps, we need to go to site and update them, using a long ... lots of time, waste a lot of time to do that, and while we are updating some more developments is taking place.

**Osiligi:** Yeah. Frankly I need more effort to be operative with the Office of City Planning; because without them I can do ... I can do nothing. They have the expertise to plan some areas, and in planning we need a lot of things. We need maps. Tandale, we don't have a map. People build whatever they want in any place. People build in the areas where the floods are too ... when it rains, water is going there very fast.

So, me and my office and the office of City Planning should collaborate in order to make the new plans and to create some infrastructures which are friendly to the people Tandale.

***Mark:*** *What sort of collaboration do you mean? Talking about what it was like without community mapping, how does the Ward of Tandale work with Kinondoni? Could you explain a bit ward and Kinondoni, what they are?*

**Juliana:** Before community mapping, it was very difficult to educate the people of Tandale, or to let them understand what we were talking about planning. But with community mapping, we grow with them step by step, they see their role, we talk to them, they see the problem, we identify the problem together with them, and it becomes easier for them to understand. Even after having the maps on a table, just like these ones, they will see where they belong, where the problems are, and where we have open land for maybe putting waste collection points and putting other services.

***Mark:*** *Tandale is a ward?*

**Juliana:** Yes. ***Mark:*** *And Kinondoni is a ...*

**Juliana:** Is a municipality.

***Mark:*** *What's the difference between those two?*

**Juliana:** The Municipality of Kinondoni have 34 wards, and out of this very few are fully planned.

**Osiligi:** Let me say since you are coming, taking these pictures from drones and other machines, I see the flashes of the new Tandale, because we have now a map and a map is something to start with. A map is something to start with because we can identify different areas, we can identify a lot of some areas to restructure, and to improve. I really appreciate 100% having these maps, because not only floods you can identify the places, but even if there is an outbreak of cholera, I can identify the places where there is an outbreak of cholera through this map. Previously, I can not do it.

I can identify some places where people are doing some illegal business through this and tell the police, "Go this way, this house, there is a problem." You see? These are the advantages of having this map. This is the roadmap for us to set the new plans, to organize ourselves, involving the community, telling them and they must have the sense of ownership that this is for them. That's the best thing, instead of us, they must have this sense of ownership: "This is ours, so we have to join our force together with the government, with the team, with the team who took these pictures, so that we can have a new plan for the year development."

***Mark:*** *You mentioned three things that I'd really like for us to discuss. That would be the uses of the map, especially the cholera, but also the engagement of how you see this going on in the future. You're talking about making Tandale planned, that relationship. Could you just give a bit more information about the cholera?*

**Osiligi:** Of course. The outbreak of cholera started in some three or four weeks ago, and we have the patients in Tandale, so how can we identify them? We go to find them. If you find a house, this is the area where the outbreak of cholera is, if I go to the map, I can see. I can direct you, "Go to the house number 642, or number 300, you can find a patient there."

***Mark:*** *So you are using this map?*

**Osiligi:** Of course we are using it, and it is very helpful to me in my working place. Not only that, but this map helped me to request the fund from the Municipal Director, because I have already now the places where there is wet, the wettest places, so that we can build there the drainage system. I have also called the sub-ward Chairmen to come to my office and tell them the areas which are wet so that we can join our force together and to do something.

***Mark:*** *Thank you. Going on from that, what are the most important to be addressed in community mapping?*

**Juliana:** In community mapping for us because we are from the local authorities, want to we really address is to provide services to community, to reach them at the grass root level because for us, we work with them and when we have a map like this one produced, it's easier. You have all the information at your fingertips so you can do it even on your table and then you go and present it to them. Without a map, it's a very long story to tell them where to put, how to do it. It becomes very difficult for them to understood but the map is a simplified way

of open data, where everybody can see and learn. It's an easier way of communication, more especially to the people at the community level.

***Mark:*** *For your in your position, what are the most important issues addressed by a community map?*

**Osiligi:** The most thing is that as mama said, the basic thing we want to improve the living standard of people because the area seems to be worse, there is no if you look, there is so roads, there's no feeder roads. There is no good plan for the household so the best thing to do is to plan the settlement of Tandale to be good and to improve the living standard of people of Tandale. Yes.

***Mark:*** *What issues does the map help you address?*

**Osiligi:** It can help you to address social issues like floods, yeah, you can identify the area which can have more floods. We can identify areas where you can put some buildings like schools, yeah.

***Mark:*** *What public services do you think will be improved now this data exists?*

**Osiligi:** I think in my working place, in Tandale, we don't have a secondary school. With this map, we can identify the place where we can put the secondary school, yeah.

**Juliana:** We can also improve accessibility within the area because accessibility open an area for development so we can improve the accessibility and through accessibility when it's improved, then other services will come automatically because you will improve the water supply, you will improve the solid waste management, you will improve the health condition of the area. Through opening up areas for transportation network, then you will improve a lot of things. You will also improve the rate of crimes in the area because if the area is accessible, then the crimes goes down, yeah.

***Mark:*** *In your opinion, what problems exist with the community mapping methods? What are the challenges that we have?*

**Juliana:** The challenges of community mapping, what I can say is it takes time to have everybody onboard, because you have to understand so that they can join you to identify the area, but I think it's a good idea. It's a very good idea because it creates a sense of ownership. Once they're onboard, they will feel that, "This is our product. We made it with our own thinking, together with these", so will always appreciate what is being in the streets.

***Mark:*** *Do you feel like that?*

**Juliana:** Yes, I do. I do, because what I see here is exactly what's in the ground, and it's really up to this map. With this, I feel very empowered that now if I want to work in Tandale, I'm working with the already existing situation, and up to date this map.

**Osiligi:** The problem we are facing in this is to sensitize people, sensitize people about this issue, because people do not know what is this, what for, why we are doing this. To implant a new idea to them, why we are doing this, sometimes it is difficult. Some people ignore you because of ignorance, but in the running world, other people understand what we mean and they collaborate with us and they support us. Like now, people are supporting us a lot through this.

***Mark:*** *How important is official data compared to the community data?*

**Osiligi:** This official data, it is better to transform to the community as they should know that this data we have belongs to them. If they know that it belongs to them it is easier for them to accept any changes which comes to them.

**Juliana:** Official data and the community data have to work together, because if you have community data and you merge it together with the community data, in that way, people in the community will accept it more than when you have the official and you say, "This is more official."

***Mark:*** *There are a few tensions with the official data?*

**Juliana:** Yes.

***Mark:*** *OK. In your professional opinions, is this data authoritative?*

**Juliana:** In my professional opinion, yes, because this is really data. This is really data, this is the best map, this is the recent best map ever for this area, so I think this is really official and because it belongs to the community, and whenever you want to succeed in the community, like us, we are local authority, we are working with the community. You have to work with the community at the best, and they have to understand you, they have to appreciate you, and they have to be really onboard with you while planning for them. This is what will take them there.

**Osiligi:** I can say that this is the real picture of Tandale, so it should get all the blessing from the government, or any other authority, because very precisely it shows everything and it reflects the real picture of the area. There is not any lying here. I do think that the authorities which bless this to be used by anyone should do it immediately without questioning, because it is the real fact about the places where you took the pictures, and it's going to help us.

**Juliana:** And maybe your point, without forgetting if at all we can have all this map like this for the whole of Kinondoni, we'll be maybe 20 steps ahead. That will really help us to reach and every corner of Kinondoni and to start to fill the gap between the development of our residents and the work that we are doing at the office. Because of our outdated maps we are left very far behind, so with maps like this one, we'll try to run and find a way of filling the gap.

***Mark:*** *Very interesting. What is the next step? How does this get better? Just to expand it, or ...?*

**Osiligi:** What I can say, we need you more and more in this. Let you not end here, because this is the beginning. You start with Tandale, in other words, but we need to see you the whole council of Kinondoni, because this is the time to change other things, and the way to change is to accept this and start in this.

**Juliana:** As I pointed out before, we have 34 wards, and out of the 34 wards only 30% of that land is planned. The rest is unplanned. Some is like Tandale, and some is not as crowded as Tandale, so if you get a map for that such land you will improve it, maybe to be just like a planned one. With this also, with the mapping or with the improvement, the council will be able to know where its citizens are, what are they doing, and it will be able also to get some revenues from them. The revenue which we take back to them for the development of Kinondoni, because what we collect from the people is not for other use other than the development of Kinondoni, so if we get maps of the other land, then everybody who is a resident of Kinondoni will start contributing to the development of Kinondoni, and that is very important.

***Mark:*** *How usable are the tools that you're using? How complicated is it for people like yourselves to go out and start mapping?*

**Juliana:** The tools that we are using?

***Mark:*** *Yes, have you used them yourselves?*

**Juliana:** Yeah, we're using different tools and we're still using the outdated Basemaps because those are the base. We can't go anywhere without a Basemap. By using that, and we used to improve them maybe sometimes using the Google map. The Google map, they don't give you the three dimension measures, they don't give you the coordinated data. With that data, sometimes when you go and do the survey, it will create a big error, sometimes it dislocate the area completely. That is one of the challenges that we really faced.

**Osiligi:** What I can say we are using the outdated technology, we need to have this new technology to invent to our areas so that we can have the land which is very precisely and clear, like what you did. I will like to advice the council to put more effort, to buy this modern machine because we need to see the modern Kinondoni, as I see the modern Tandale.

***Mark:*** *What sort of modern machines would you like to see?*

**Osiligi:** I'd like to see the Drones, I'd like to see those machines like 'bazooka' and the Bajaj. We call it Trim or what? Trimble, yes, it is called Trimble. **Juliana:** In the past we used to have aerial photos which are taken by aeroplanes. In order to be able to do that, you need to have a clear sky without any clouds. All the time when they come they say, ah, it's too cloudy,

we can't see, it can't work. With Drones, it's just like that, you get the information. You don't have to go to the clouds.

***Mark:*** *You want to see it across all of Kinondoni?*

**Juliana:** Yes.

***Mark:*** *You think that it's going to take a long time and a lot of resources? Do you think there are different ways to do it, to get the maps, instead of using community mapping?*

**Osiligi:** Well, myself, what I see is that, this map took a short time period to take it, and to create the way it is, so we don't need to spend more time because we have already note there are tools which can use the short of time, so let us invest in those tools.

After having that, we'll map the whole Kinondoni that the 34 wards to map with drone, it will take only 3 month I think; it's finished. Yeah, and we will use those drones. Even when it comes to rain, you need to know the flooding zone, how the flood affected the area, you fly the drone then it give you the area which is flooded. Immediately, you know the coverage of the problem.

***Mark:*** *How do you see yourselves updating these maps?*

**Juliana:** Updating the maps, it's a process which you can't avoid it. Even with the other technology, it use to be the same. Because after taking the area photos, you'd really need to go and upgrade it, but using the community, it's easier because, the community has much more knowledge. The community have much more knowledge of their area. They're conversant with their area, so it takes even more little time to do the updating.

**Osiligi:** This map has been putting in the website. If you want to update, you can update, and I've got the knowledge. They teach me how to add other things, the new house, the new location. Yeah, I can do it. I can add anything, yeah.

***Mark:*** *What are the incentives for people to do this? Why would the community update the map?*

**Osiligi:** Basically, the community is growing day after day, so there is new structure. There is new developments. There are changes, so we need to include and exclude those changes. If you exclude something, you need to exclude in the map. If you include something, you have to include the map. You must have the real picture of that place.

***Mark:*** *Cool.*

**Osiligi:** These maps going to help because Tandale, we don't have the public water system, so using this, we can go to the Authority, DAWASCO to ask for them to come that we have the map. We can use this way to put your pipes. You can go this way, you put your pipes, so that we can have water because we don't have water in Tandale. We're using wells, that's why even

the outbreak of this cholera associated with wells' water, so using this map, we can collaborate with people, with DAWASCO to have the public water system.

**Juliana:** Even with floods, the Municipal Council is engaged fully to deal with the people who are affected with floods, but also to identify those houses which are being flooded. During the 2012 floods, the Department of Urban Planning was engaged in going to count house after house to identify all those flooded houses, and all the flood victims were the subject of the Municipal Council, so to identify the flood prone areas at the right time, if we have a map to do so, it will be very great to the Municipal Council.

# Appendix B

# Expanding CWA

This appendix further expands on the CWA discussed in Chapter 6. It builds upon the CWA, specifically by expanding the decision ladders and strategies analysis of the CWA of community mapping.

## B.1 Decision Ladders

Decision ladders are discussed in section 3.2.3.2 and allow for an understanding of the activity in decision making terms to decompose the work domain. Boxes represent information processing activities and ovals represent states of knowledge. Here, the Skills, Knowledge and Reflex (SKR) states are also identified, with leaps and shunts allowing for changes of states based upon the level of the mapper concerned.

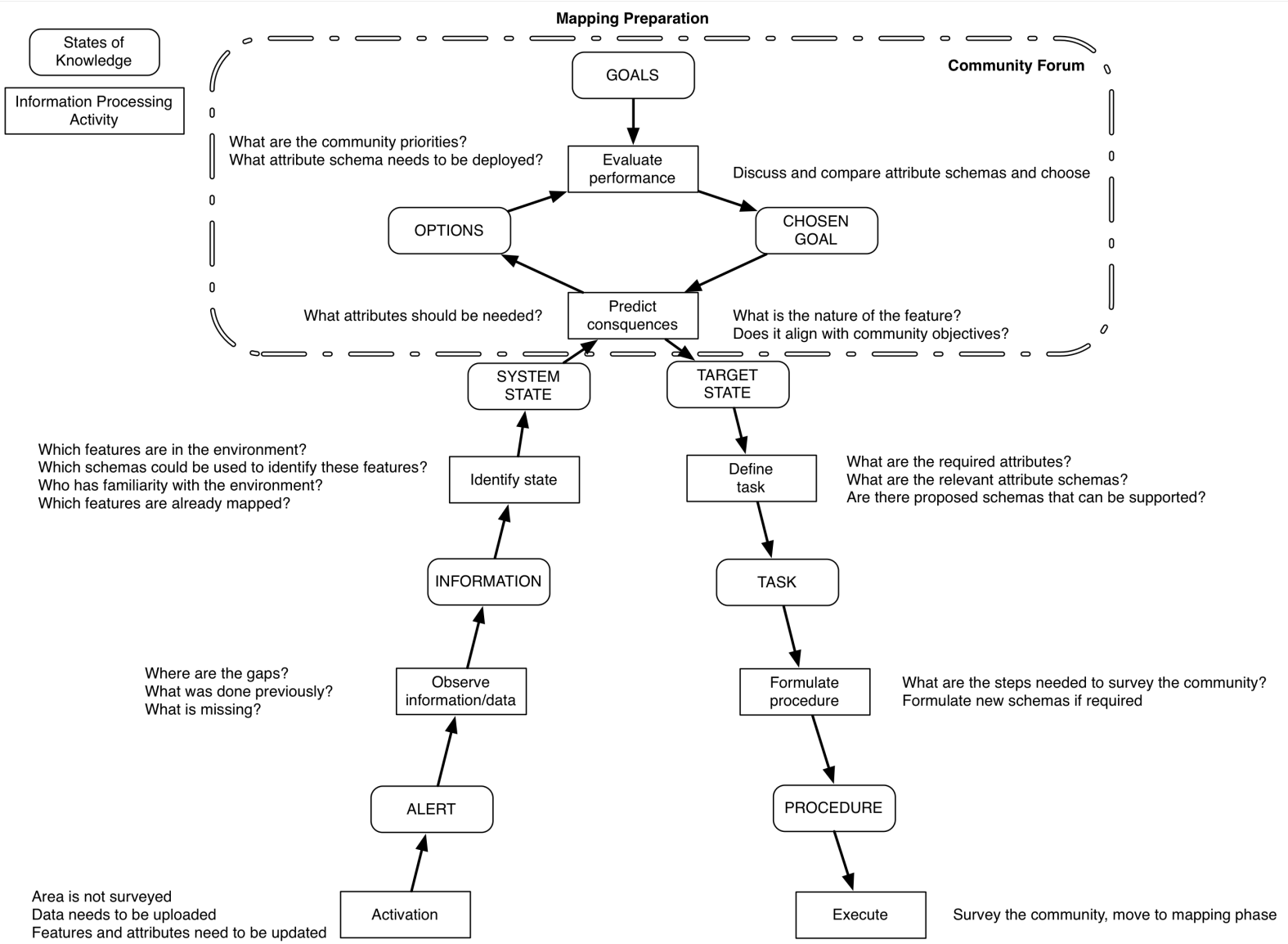


Figure B.1: Preparation Decision Ladder

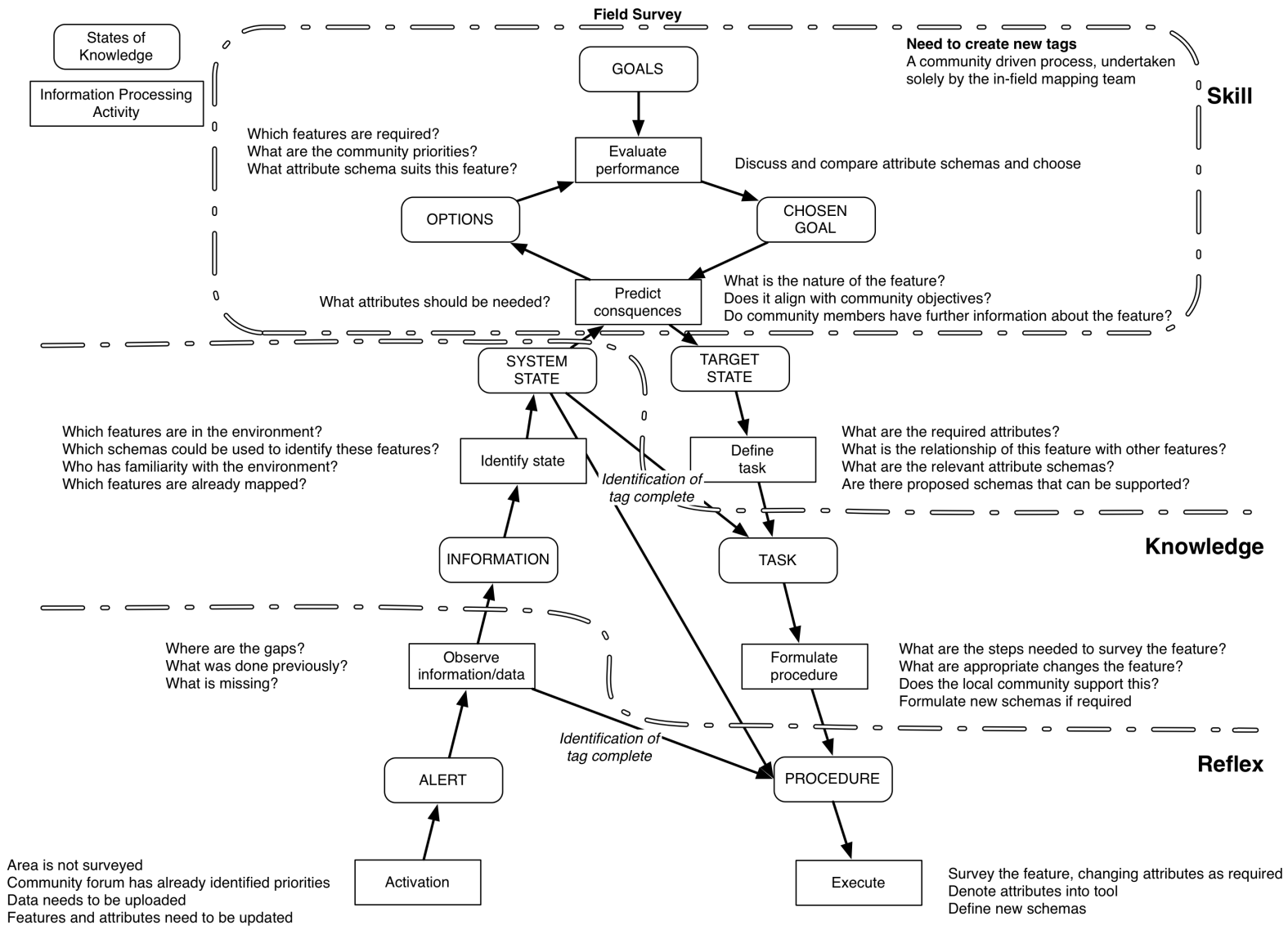


Figure B.2: Mapping Decision Ladder

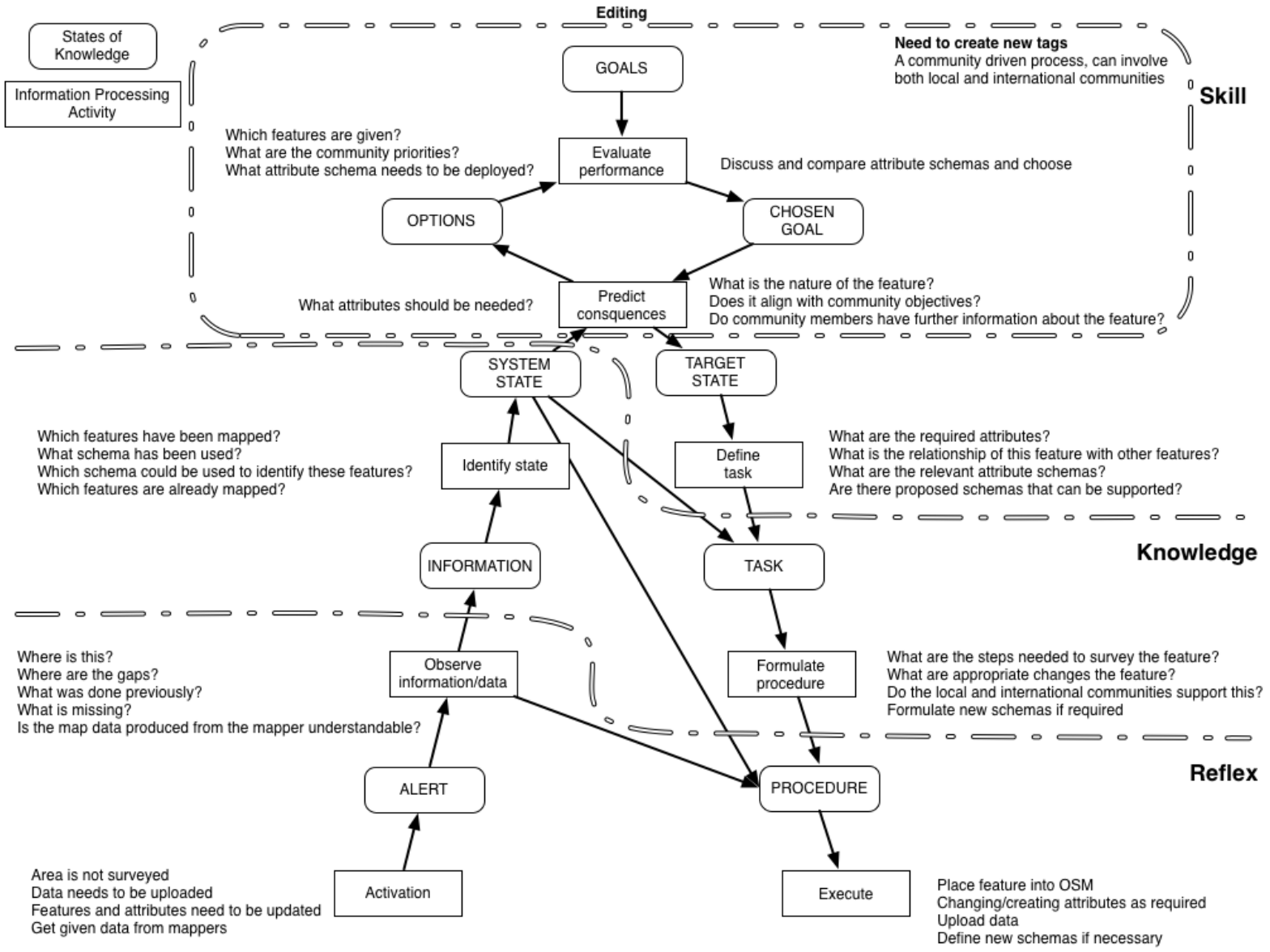


Figure B.3: Editing Decision Ladder

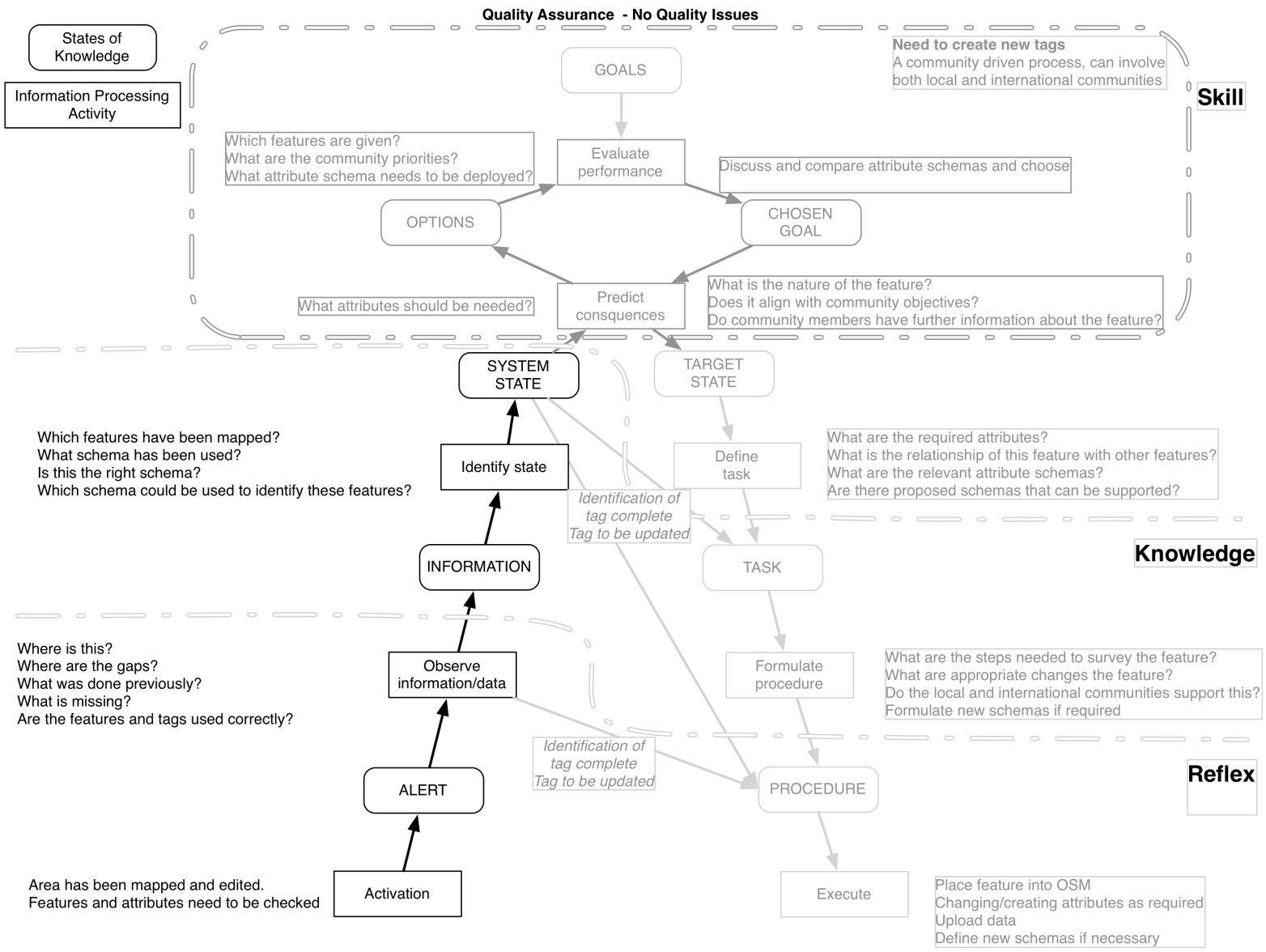


Figure B.4: Quality Assurance - No Data Issues - Decision Ladder

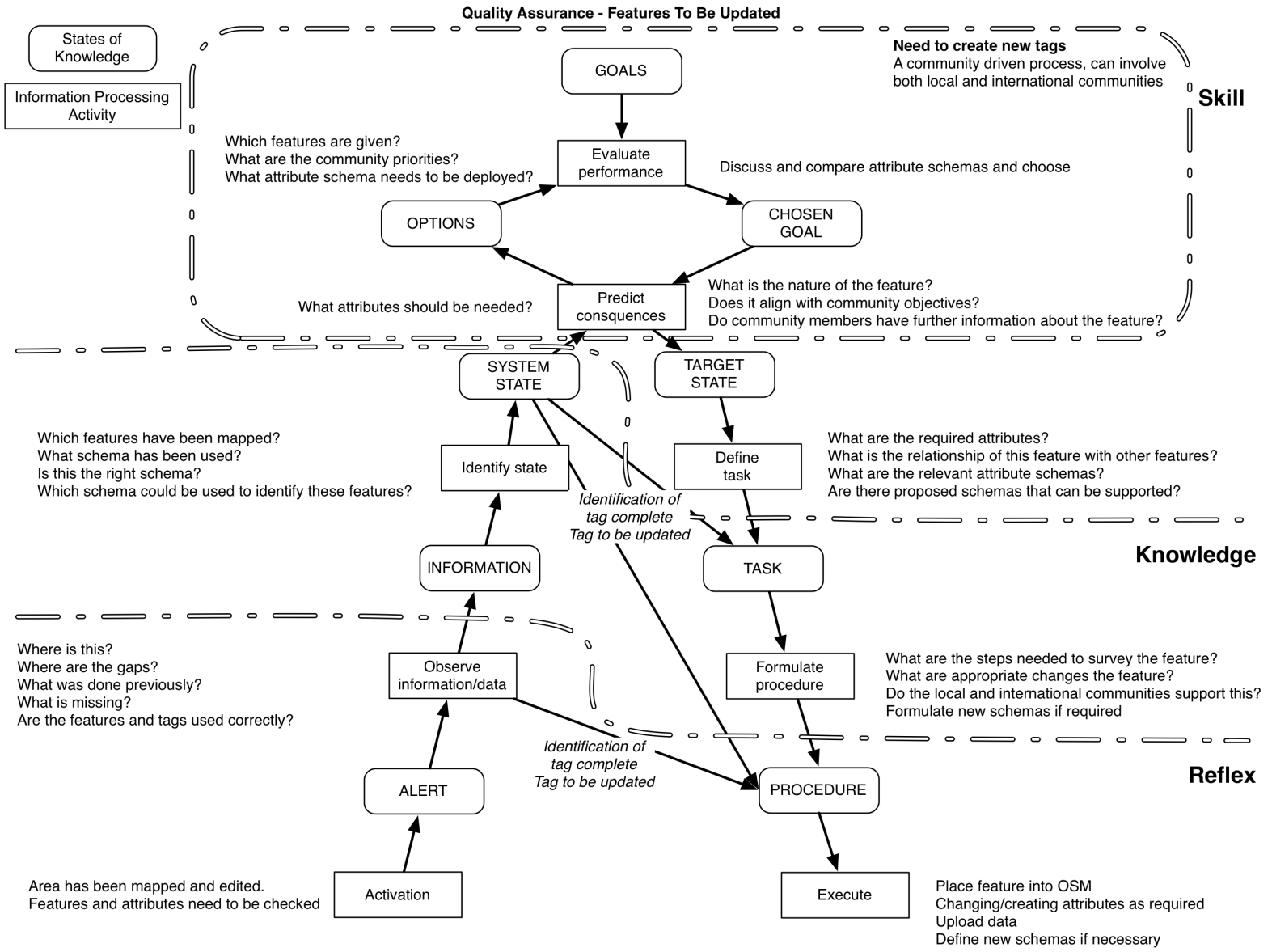


Figure B.5: Quality Assurance - Data Issues - Decision Ladder

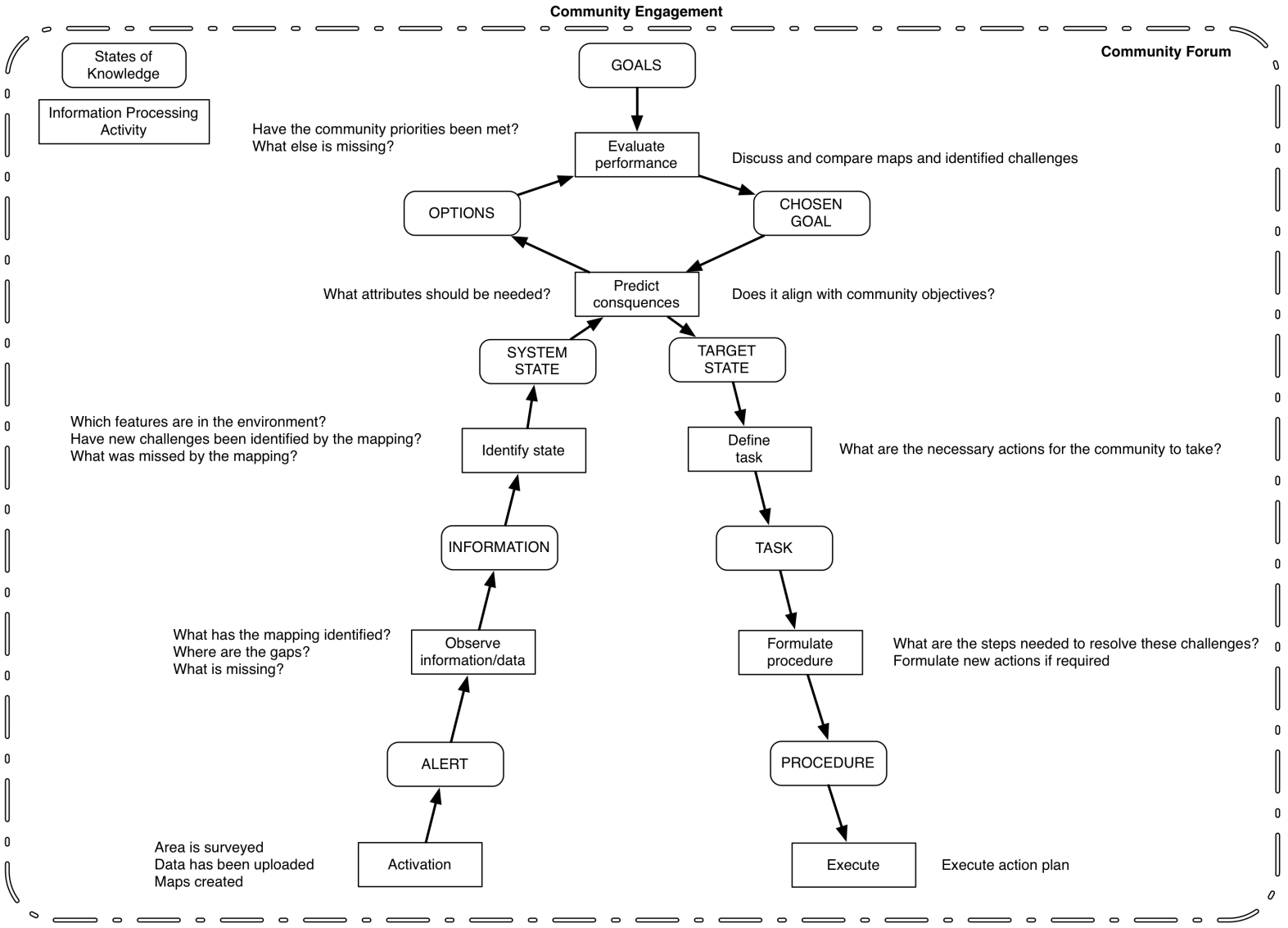


Figure B.6: Community Engagement Decision Ladder

| Decision Ladder | Stage | Definition |
|---|---|---|
| B.1 | Preparation | The **preparation** situation is primarily undertaken by the *organisers*, with the function of communication undertaken by all roles. There are no leaps or shunts, as the process needs fully involve the community, through a community forum. If leaps and shunts were to occur, this would indicate that there is less citizen participation and more tokenism within the process of community mapping. |
| B.2 | Field Survey | The **field survey** situation is primarily undertaken by the *mappers* and *catalysts*, incorporating communication with the *organisers* and *public* when in the field. This could be through identifying features to be mapped and discussing specific attributions of features with the broader community to elicit information. This can be stratified into the SKR taxonomy. For example, an experienced mapper on mapping a water point will not follow the full decision making process; they will not investigate the appropriate schema. Instead, they will map the feature by reflex, as they have full understanding of the feature and its mapping schema: leaping across the ladder. By contrast, an inexperienced mapper will not follow this pattern, they will investigate the schema, investigating the task further. |
| B.3 | Editing | The **editing** situation is primarily undertaken by *editors* and *tracers*, incorporating feedback and discussion from the *mappers* with direction from the *catalysts*. This is also stratified by SKR, where experienced editors will be able to recall and apply experience of the mapping taxonomy to input data. This is challenged when there is no feature attribute taxonomy available. Here a discussion could occur within the local group and potentially the wider global community to ascertain the correct tags and attribute schema, prior or after the mapping process. |
| B.4 | Quality Assurance no issue | The **quality assurance** situation is primarily undertaken by *editors* and *tracers*, under the direction of *catalysts*. This ladder indicates no quality issues with the feature that the mapper is interrogating. Through traversing the ladder, the mapper identifies the feature and its state, finding that there are no issues to report. Consequently, the system state remains unchanged as the feature is as it is supposed to be. |

| Decision Ladder | Stage | Definition |
|---|---|---|
| B.5 | Quality Assurance quality issue | This decision ladder complements the above discussion, though, indicates a situation where there is a data quality issue, for example a feature tag being incorrectly entered. As per the editing scenario, it is possible that an *editor* has incorrectly filled in a feature, with an attribute that currently not created. In this scenario, in identifying that new tags need to be created, this goal is discussed with a wider group, possibly the wider community too. Through using the SKR stratification, it is also possible to leap and shunt towards task identification and procedure action by experienced mappers, once the quality issue is observed and/or identified. |
| B.6 | Community Engagement | The *community engagement* situation primarily engages *storytellers* and *public* roles, with support from all other roles. This situation is primarily undertaken through a communtiy forum, either during, or at the end of the mapping phase. As per the *preparation* situation, if leaps and shunts were to occur, this would indicate that there is less citizen participation and more tokenism within the process of community mapping. |
| | Post Initial Mapping | There is the omission of the decision ladder for the *post initial mapping* situation, as, in effect, this mirrors the *mapping preparation* situation, albeit with the added participation of community *catalysers*. As there is a map created, it is also possible for the *public* to use the map and for *organisers* to use the output in support of SDI and other geospatial information related functions. |

Table B.1: Discussion of Decision Ladders, within the SOCA-CAT

## B.2 Strategies Analysis

Strategies Analysis is discussed in section 3.2.4 and allow for a deeper understanding of how activities can be conducted, identifying the various strategies that mappers can achieve a goal. Here, the strategies the various strategies have been further stratified by the role undertaking the task. Specifically in this section, the formative situations of *Mapping, Editing, Tracing* and *Quality Assurance* are considered as they have various stratagems that could be employed, depending on the constraints within the work environment.

### Lines: Road and Drains

The features of roads and drains are similar to other geographic features that are lines (e.g. power cables), in that there are various stratagems that can be employed to capture feature attributes. In both Figures B.7 and B.8, the various approaches are denoted, showing the various roles and constraints. The *mapper* role and the top two pathways, require a GPS receiver. From this point, they have the option to stay stationary and chart the feature through waypoints on a GPS receiver or by walking along the route. Similarly, the bottom approach allows for the same end to be achieved, though is done without a GPS receiver, instead using field papers, a pen, and paper.

In the second from bottom approach, employed by the *editor* and *tracer* roles, the same end is achieved in surveying the feature, but without being physically located there. Notably, there is less opportunity to gather as detailed information with this approach, as this will be constrained by the quality of the imagery used to digitise the feature. Alternatively, this could be augmented by data from *mappers* in the field.

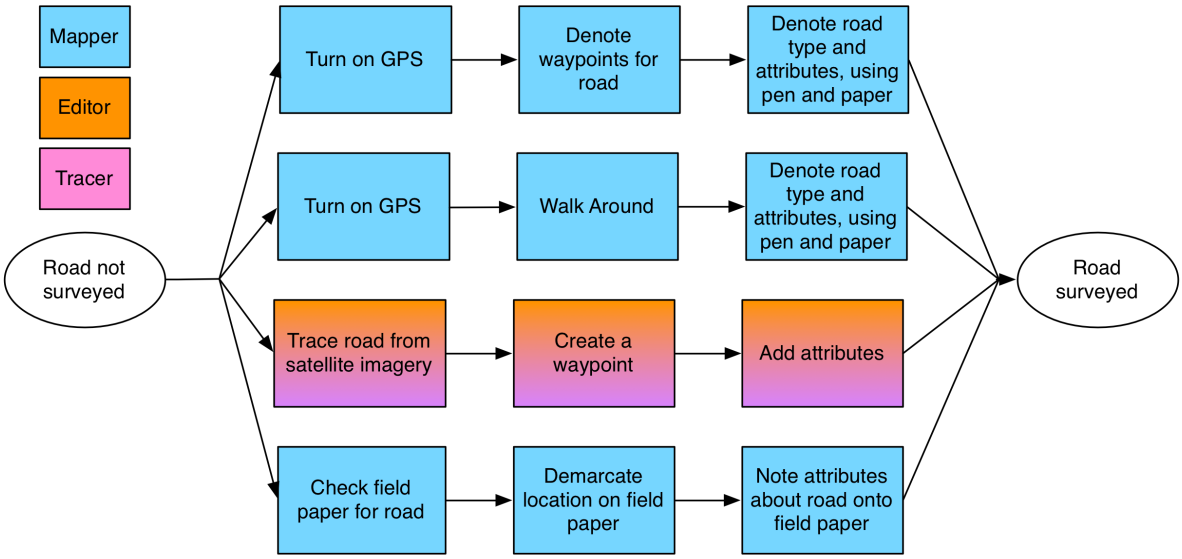


Figure B.7: Road Strategies Analysis

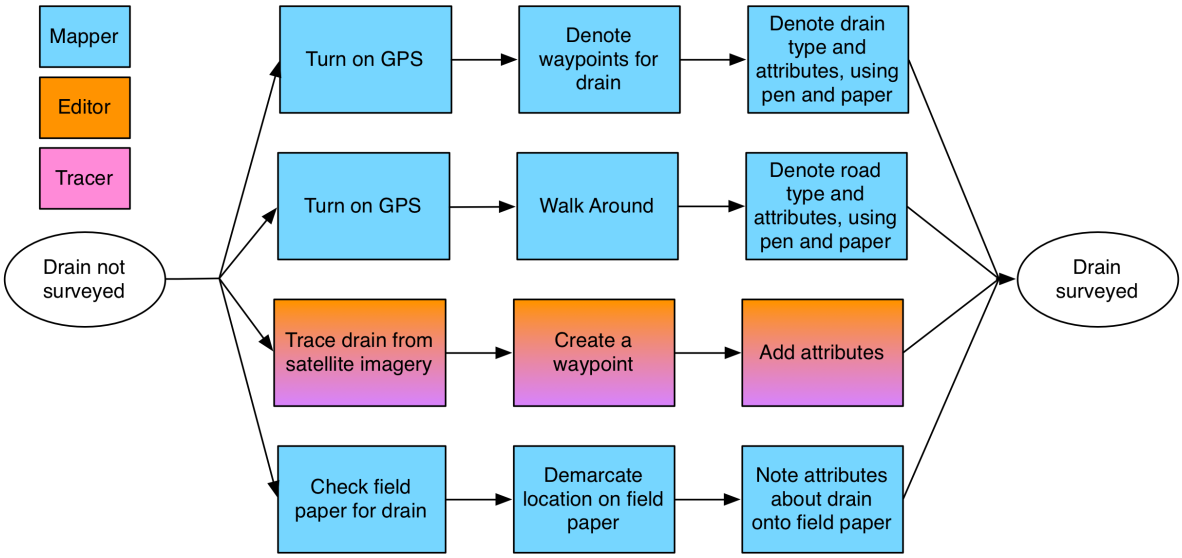


Figure B.8: Drain Strategies Analysis

## Point: Water Point and Lamppost

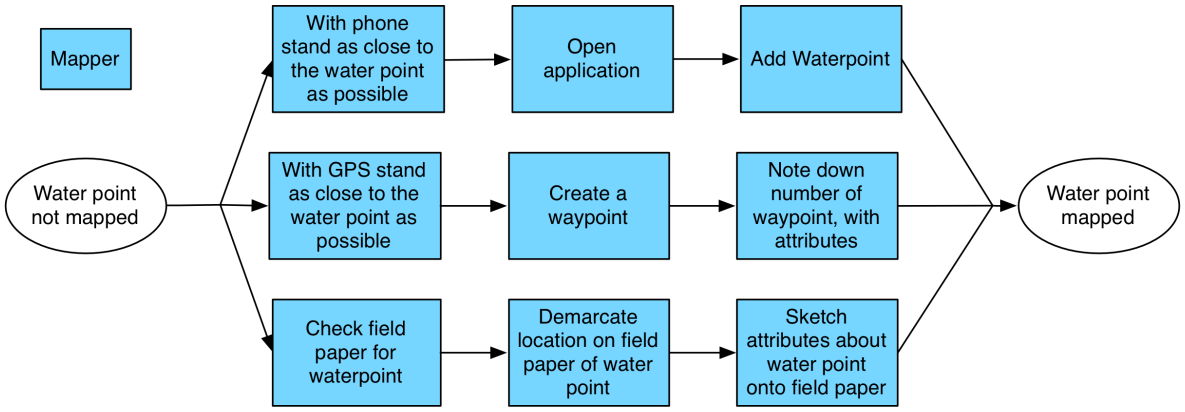


Figure B.9: Water Point Strategies Analysis

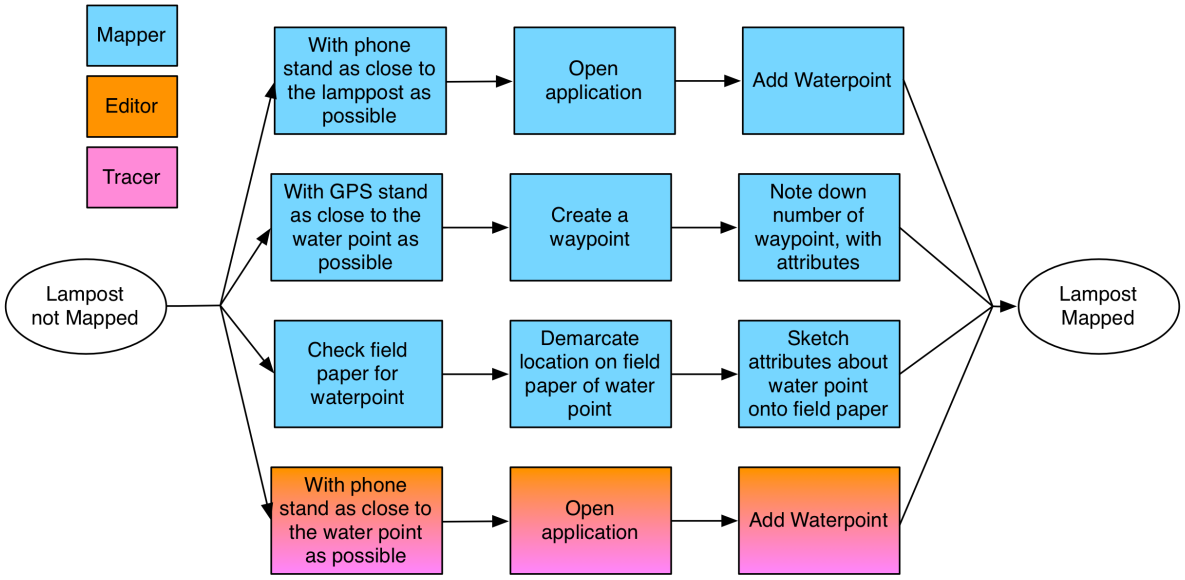


Figure B.10: Lamppost Strategies Analysis

The features of water points and lampposts have similar properties to other geographic features that are point based (e.g. trees). In both Figures B.9 and B.10, the various strategies are examined. For these two point data types, the selection of the appropriate strategy of feature capture is predicated on the constraints of scale and location. Features such as lampposts are usually discernible from aerial imagery, and as such could be surveyed by *editors* and *tracers*. In contrast, water points, even with the highest of quality aerial imagery would be impossible to discern remotely, accordingly this would remain an activity that needs to be conducted by *mappers* on the ground.

## Area: Building and Landuse

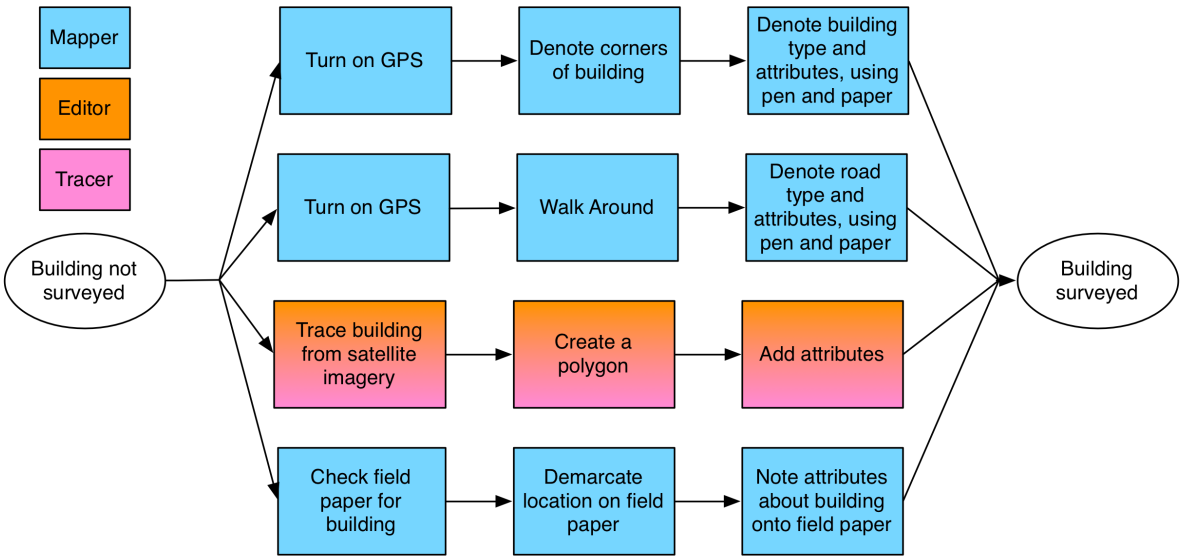


Figure B.11: Building Strategies Analysis

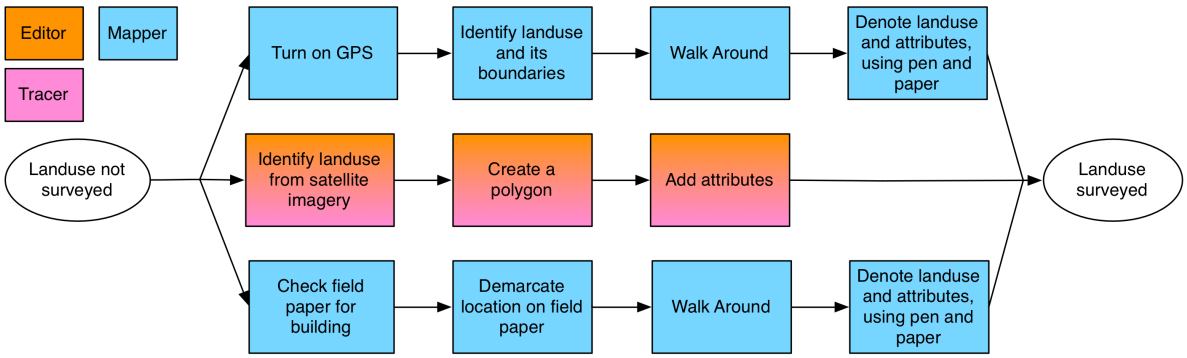


Figure B.12: Landuse Strategies Analysis

The features of buildings and landuse have similar properties to other geographic features that are polygon based (e.g. waterbodies). Both Figures B.11 and B.12 examine the various constraints that enable the collection of data and by the roles. As with the above section, there is a separation between field and remote mapping. For example, there is a shortening of steps for the remote mapping of landuse: the aerial perspective allows for quicker definition of the extent of landuse to be achieved. If undertaken by a mapper on the ground, this would have to be established through travelling the feature extent, greatly adding to the time and complexity of surveying the feature, consequently, adding to the potential that data will be collected in a manner that could compromise its quality.

### Editing, Tracing and Quality Assurance

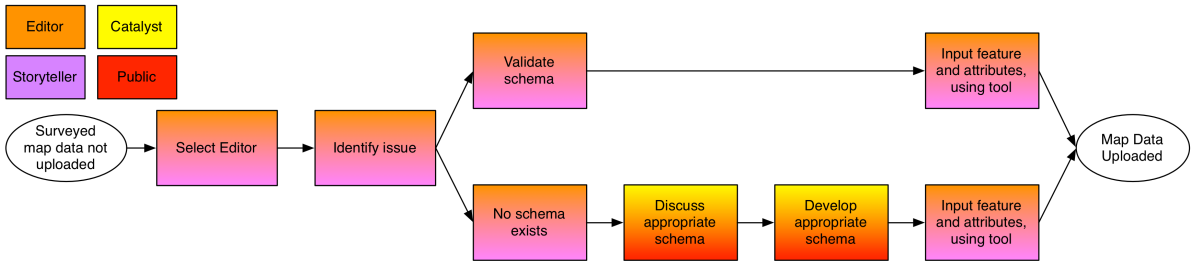


Figure B.13: Editing, Tracing and Quality Assurance Strategies Analysis

The *Editing, Tracing* and *Quality Assurance* strategies are thematically similar, in that they each involve the selection of a tool, identification of a feature and its attributions, validation of the schema, and uploading into the database. The pivot point is the schema. If there is an established schema, then uploading to the database once data is inputted/validated occurs - in effect 'leaping' to the end. If not, a schema needs to be created. This is examined in Figure B.13, the *catalyser* supports the identification of attributes, either through defining a new schema in collaboration with the public (locally through establishing feature attributes with the community, and/or with the wider global commons). Once this has been established, data input can occur.

## Synopsis

The above situations contrast with *Preparation, Community Engagement* and *Post Initial Mapping* in that these do not merit the same level of analysis, as there are no complementary strategies for their implementation. *Community Engagement* through community forums are organic gatherings, focused around a community's needs and are not technology enabled. By being focused around space and willingness in the community, constraints of technology do not enter into the situations' work domain. Similarity, the *Preparation* and *Post Initial Mapping* situations are thematically similar[1] they are not technologically linked, nor do they require community strategy regarding the development of features and as such are critical components of the CWA, but do not merit the same level of formative analysis.

[1]Whilst the function of *navigation* is under the Post Initial Mapping situation, it is beyond the scope of this thesis to discuss the various strategies that communities use for navigation, this could be technologically based or using landmarks etc.

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